Kansanterveyslaitos
Folkhälsoinstitutet
National Public Health Institute

Kansanterveyslaitoksen julkaisuja A12/2001

Publications of the National Public Health Institute

Marjaana Lahti-Koski

BODY MASS INDEX AND OBESITY AMONG ADULTS IN FINLAND

Trends and determinants

Academic Dissertation

To be presented, with the permission of the Medical Faculty of the University of Helsinki, for public examination in the Small Hall, University Main Building, on November 9, 2001, at 12 o'clock.

Department of Epidemiology and Health Promotion,
National Public Health Institute and
Department of Public Health,
University of Helsinki

Helsinki, Finland
2001

Publications of the National Public Health Institute (KTL) A12/2001

Julkaisija – Utgivare – Publisher

Kansanterveyslaitos (KTL)
Mannerheimintie 166
00300 Helsinki
Puhelin vaihde (09) 474 41, telefax (09) 4744 8408

Folkhälsoinstitutet
Mannerheimvägen 166
00300 Helsingfors
Tel. växel (09) 474 41, telefax (09) 4744 8408

National Public Health Institute
Mannerheimintie 16
FIN-00300 Helsinki, Finland
Telephone +358 9 474 41, telefax +358 9 4744 8408

ISSN 0359-3584
ISBN 951-740-234-1
ISBN 951-740-235-x (PDF)

Hakapaino Oy
Helsinki 2001

To my family

Supervisors

Professor Pirjo Pietinen
Nutrition Unit
Department of Epidemiology and Health Promotion
National Public Health Institute
Helsinki, Finland

Professor Erkki Vartiainen
Chronic Disease Epidemiology and Prevention Unit
Department of Epidemiology and Health Promotion
National Public Health Institute
Helsinki, Finland

Docent Markku Heliövaara
Department of Health and Functional Capacity
National Public Health Institute
Helsinki, Finland

Reviewers

Professor Seppo Sarna
Department of Public Health
University of Helsinki
Helsinki, Finland

Professor Jacob C Seidell
Department of Chronic Diseases Epidemiology
National Institute of Public Health and the Environment
Bilthoven, The Netherlands

Opponent

Professor Aila Rissanen
Obesity Research Unit
Helsinki University Hospital
Helsinki, Finland

Contents

Abstract

Six cross-sectional population surveys have been carried out at five-year intervals starting in 1972 in eastern Finland. Since then, weight and height of Finnish adults have also been monitored regularly. The objective of the present study was to assess trends in body mass index (BMI), waist-to-hip ratio (WHR) and obesity among adults in Finland during the last few decades. A further aim was to identify possible risk groups for increasing obesity by investigating the associations of BMI and obesity with age, education, occupation and lifestyle factors.

This study is part of the national FINRISK studies carried out between 1972 and 1997. These surveys covered two eastern regions in 1972 and 1977 but were expanded to include a third region in southwestern Finland in 1982. For each survey, an independent random sample from the national population register was drawn of subjects aged 25 to 64 years. Altogether 45 777 randomly selected men and women participated in the six surveys. Weight, height, and waist and hip circumferences of subjects were measured, and data on occupation and education level as well as lifestyle factors were collected by self-administered questionnaires.

The mean BMI increased in both genders. In men, the upward trend was most prominent in the oldest age group (55-64 years), but was also found in the youngest age group (25-34 years), whereas in women, the upward trend was greatest in the youngest age group. A BMI increase with age was more prominent in women than in men and was very similar in all birth cohorts. In men, the BMI increase with age varied across cohorts such that the younger the cohort, the greater the BMI increase with age. Independently of changes in BMI, abdominal obesity increased both in men and women during the ten-year period, especially among subjects aged 45 years or older. In men, the strongest upward trend in WHR occurred in the early 1990s, whereas in women, these trends continued steadily throughout the 1990s.

BMI increased in all educational groups in men, but in women, the upward trend seemed to be greatest in the lowest educational group. The upward trends were most prominent among retired and unemployed men, whereas in women, BMI changes over the years did not vary across occupational groups.

Physical activity, no smoking, moderate alcohol consumption and healthy food choices were associated with the least likelihood of being obese. The significance of avoiding sedentariness seemed to increase over time as a factor associated with normal weight.

List of original publications

This thesis is based on the following original publications referred to in the text by their Roman numerals (I-IV):

I Lahti-Koski M, Vartiainen E, Männistö S, Pietinen P. Age, education and occupation as determinants of trends in body mass index in Finland from 1982 to 1997. *Int J Obes Relat Metab Disord* 2000;24:1669-1676.

II Lahti-Koski M, Jousilahti P, Pietinen P. Secular trends in body mass index by birth cohort in eastern Finland from 1972 to 1997. *Int J Obes Relat Metab Disord* 2001;25:727-734.

III Lahti-Koski M, Pietinen P, Männistö S, Vartiainen E. Trends in waist-to-hip ratio and its determinants in adults in Finland from 1987 to 1997. *Am J Clin Nutr* 2000;72:1436-1444.

IV Lahti-Koski M, Pietinen P, Heliövaara M, Vartiainen E. Associates of body mass index and obesity with physical activity, food choices, alcohol, and smoking in the 1982-1997 FINRISK studies. *Am J Clin Nutr,* in press.

These papers are reproduced with the permission of the publishers: Nature Publishing Group (I-II) and the American Society for Clinical Nutrition (III-IV).

Abbreviations

BMI	body mass index
CI	confidence intervals
CT	computerized tomography
CVD	cardiovascular diseases
DEXA	dual energy X-ray absorptiometer
MET	metabolic equivalent
MRI	magnetic resonance imaging
OR	odds ratio
sd	standard deviation
SES	socioeconomic status
WHO	World Health Organization
WHR	waist-to-hip ratio

1. Introduction

The negative effects of obesity on health are beyond dispute. Excessive body fat represents a strong risk factor for several diseases, the most important of which ones are type 2 diabetes, hypertension, cardiovascular diseases and osteoarthritis (Pi-Sunyer 1991, World Health Organization 2000). Most of these deleterious effects are more likely if the excess body fat is mainly stored in the upper body, with abdominal visceral fat being the most critical when evaluating the health risks of obesity (Pi-Sunyer 1991, Björntorp 1993, World Health Organization 2000). Moreover, obesity is associated with disability and poor perceived health (Wolk and Rössner 1996, Manderbacka et al. 1998, Doll et al. 2000, Ford et al. 2001).

Obesity not only has wide-reaching medical consequences but also has social and economic implications (Seidell 1995a, Wolf and Colditz 1996). Obese subjects are more likely to have frequent sick leaves and to be prematurely pensioned (Rissanen et al. 1990, Moens et al. 1999). In addition, subjects overweight in adolescence have been shown to complete fewer years of education and to be less likely to get married than their normal-weight counterparts (Gortmaker et al. 1993). In women, overweight has been associated with lower household income (Gortmaker et al. 1993, Sarlio-Lähteenkorva and Lahelma 1999) and unemployment (Sarlio-Lähteenkorva and Lahelma 1999). Stigmatization and impaired well-being of obese subjects have been established in several studies (Crocker et al. 1993, Myers and Rosen 1999).

The obesity-related burden for society is considerable as well. Estimations of economic costs incurred range from 2% to 7% of total health care costs, which means that obesity represents one of the largest expenditures in health care budgets (Seidell 1995a, Wolf and Colditz 1996, 1998, Swinburn et al. 1997). In

Finland, the corresponding figure is similarly estimated to range from 1.4% to 7% (Pekurinen et al. 2000).

Obesity has been suggested to be a major avoidable contributor to the costs of illness in the United States (Colditz 1992, Wolf and Colditz 1996). Nevertheless, its prevalence continues to increase, not only in the United States but worldwide (Popkin and Doak 1998). Thus, obesity is also an escalating health problem in European countries (Seidell 1995b, World Health Organization 2000), including Finland, where its high prevalence and increasing trend were already observed in the 1970s (Rissanen et al. 1988). The mean body mass index (BMI) continued to increase steadily in men during the 1980s and the early 1990s, whereas in women, BMI trends reversed in the early 1980s and then seemed to level off (Pietinen et al. 1996).

Difficulties in treating obesity and maintaining weight loss are well documented. Indeed, prevention appears to be the most promising way of overcoming this growing epidemic (Bouchard 1996, Gill 1997). However, interventions aimed at prevention of obesity or weight gain are scarce and few studies have been done (Glenny et al. 1997, Hardeman et al. 2000). Thus, limited information is available for formulating effective obesity prevention strategies. When planning prevention policies, more knowledge is needed about factors being attributed to this escalating problem (James 1995). Monitoring changes in BMI and in the prevalence of obesity over time are essential for evaluating strategies and actions for the prevention and management of obesity.

This thesis describes changes in body weight and obesity among Finnish adults both overall and by age and socioeconomic factors over a 15-year period, partly also over a 25-year period. The specific objective was to identify possible risk groups for undesirable trends in obesity. The associations of lifestyle factors with obesity and BMI, and their consistency over time were investigated as well.

2. Review of the literature

2.1. Definitions and classification of obesity

2.1.1. BMI as a measure for assessing obesity

Obesity is characterized by excess adipose tissue. Quantification of adipose tissue mass can be achieved by a number of laboratory methods including underwater body density measurement and body fat content estimated by the dual energy X-ray absorptiometer (DEXA). In addition, the development of new techniques, such as magnetic resonance imaging (MRI) and computed tomography (CT), has provided researchers with opportunities to describe human adiposity in more detail (Lukaski 1987, Seidell et al. 1987, Gray et al. 1991, Sobol et al. 1991). However, these methods require costly equipment and are difficult to implement in epidemiological studies, although some exceptions exist, such as bioelectrical impedance (Jebb and Elia 1993).

In large-scale population surveys, body weight adjusted for stature (body mass index) is commonly used as a surrogate for body fat content (Revicki and Israel 1986, Gray and Fujioka 1991). These indices are defined as different combinations of weight and height, such as weight divided by height and weight expressed as a percentage of mean weight for a given height and sex (Colliver et al. 1983). The most widely used is Quetelet's index, better known as body mass index (BMI), which is body weight (kg) divided by height squared (m^2). This index has been shown to correlate weakly with height and strongly with body fatness (Keys et al. 1971, Revicki and Israel 1986).

Although the correlation between BMI and body fat adjusted for height is high (r=0.82-0.91) (Spiegelman et al. 1992), BMI fails to distinguish between lean body mass and fat. Thus, the relationship between BMI and body fatness varies according to body composition proportions (Garn et al. 1986). For instance, the percentage of body fat mass is higher in women than in men with a similar BMI. In addition, body fatness has been shown to increase with ageing, meaning that a given BMI may correspond to a greater body fat content in older subjects compared with younger ones (Ross et al. 1994, Gallagher et al. 1996).

Any age-related change in height has an influence on BMI as well. In adults, height is lost with normal ageing. In a recent study, an average height loss of 3 cm from age 30 to 70 years was estimated to account for an artificial increase in BMI of 0.7 kg/m^2 for men. In women, the height loss averaged about 5 cm over the same 40-year period, accounting for an increase of 1.6 units in BMI (Sorkin et al. 1999). During growth in childhood and adolescence, not only does height increase but body composition changes as well, thus classification of obesity according to BMI is complicated. Because the age of onset of puberty varies, international BMI-based estimates of overweight in children and adolescents are rendered even more difficult to determine (World Health Organization 2000). The need for these estimates has, however, been emphasized (Prentice 1998). Consequently, internationally based cut-off points for children have recently been published (Cole et al. 2000).

Despite its limitations, BMI provides a simple and the most useful population-level measure of obesity in adults. A BMI of 30 kg/m^2 is widely recognized as a cut-off point for obesity. The latest classification of overweight according to BMI (*Table 1*) was introduced in a WHO report published in 2000 (World Health Organization 2000).

Table 1. Classification of under- and overweight in adults according to BMI.

Classification	**BMI (kg/m^2)**	**Population description**[1]
Underweight	<18.5	Thin
Normal range	18.5-24.9	Normal, healthy, acceptable weight
Overweight	≥25	
Pre-obese	25-29.9	Overweight
Obese class I	30.0-34.9	Obesity
Obese class II	35.0-39.9	Obesity
Obese class III	≥40	Morbid obesity

[1] adapted from Seidell and Flegal 1997

Source: World Health Organization 2000

The BMI-based classification of overweight and obesity has been well received by the research community (Seidell et al. 2001), making comparisons for obesity prevalence between or within populations feasible. However, in some studies, alternative cut-off points have been used. For example, obesity has been classified on the basis of the BMI distribution in the reference population, the 85th percentile being the cut-off point for overweight and the 95th percentile for obesity (Kuczmarski et al. 1994, Yanai et al. 1997), or subjects with a relative weight index (100 x weight divided by ideal weight) larger than 130% have been considered to be obese (Laurier et al. 1992).

It must be acknowledged, however, that the classification of obesity according to BMI is artificial, and the cut-off point of BMI 30 for obesity is purely arbitrary. The population is not composed of two distinct groups, namely the obese and the non-obese. The cut-off point for obesity merely indicates the greatly increased health risks above this level of body fatness. It does not, however, imply that BMI below this level is free from associated risks because the risks of morbidity and mortality begin at relatively low levels of BMI (Manson et al. 1995, Willett et al. 1995, 1999, World Health Organization 2000). Overall, guidelines for healthy weight are difficult to determine (Garn 1996, Cooper et al. 1998, Willett et al. 1999, Liu and Manson 2001).

2.1.2. Abdominal obesity

Recently, the relationship between body-fat distribution and several diseases, independent of overall obesity, has attracted much attention. It has become increasingly clear that not only the amount of fat deposited on the body but where it is situated is responsible for the increased risk for such diseases as cardiovascular disease (Lapidus et al. 1984, Larsson et al. 1984, Kannel et al. 1991, Folsom et al. 1998, Rexrode et al. 1998, Megnien et al. 1999), non-insulin diabetes mellitus (Hartz et al. 1983, Carey et al. 1997) and breast cancer (Männistö et al. 1996b, Kaaks et al. 1998).

The importance of fat distribution was recognized already in the middle of the last century, when subjects with an android body type (upper body fat accumulation) were shown to have a higher probability of various diseases than gynoid-type subjects (lower body fat accumulation) (Vague 1956). More recently, the absolute amount of intra-abdominal fat rather than the fat distribution pattern has been suggested to influence health risks (Kahn 1993), although the independent contribution of visceral fat accumulation to disease development is still under review (Seidell and Bouchard 1997).

Numerous techniques have been developed for the assessment of visceral fat. The most valid and reliable estimates of abdominal visceral fat can be obtained by using imaging techniques such as computerized tomography (CT) and magnetic resonance imaging (MRI) (van der Kooy and Seidell 1993). These techniques are also able to differentiate between subcutaneous and visceral abdominal fat (Ashwell et al. 1985, Sobol et al. 1991). However, these methods are laborious and expensive. In addition, involvement of radiation exposure with CT limits the frequency of measurements (Jebb and Elia 1993, van der Kooy and Seidell 1993). Therefore, these techniques are not suitable for screening large groups of individuals (Molarius and Seidell 1998, Rankinen et al. 1999).

For epidemiological studies, simple yet valid anthropometric indicators of visceral obesity are needed. In this case, BMI is not suitable because it cannot distinguish between lean body mass and fat, much less between visceral and subcutaneous fat. A variety of other anthropometric indicators have been suggested as optimal predictors of visceral fat. However, all of them have limitations either in the interpretation of results or in their use for public health purposes (Després et al. 1991, Molarius and Seidell 1998).

The most commonly used indicator is the waist-to-hip ratio (WHR), which was initially proposed in Sweden (Krotkiewski et al. 1983) and in the United States (Hartz et al. 1983) at the beginning of the 1980s. WHR rather than waist circumference alone was used because the latter was considered to be highly dependent on the stature of the individual measured. WHR has been shown to be a good predictor of visceral fat (Ashwell et al. 1985, Seidell et al. 1987, 1988), although some variation occurs with age (Seidell et al. 1988).

The ratio of waist to height has also been used as an indicator of abdominal fat (Higgins et al. 1988), as has the conicity index, with which the abdominal girths of persons of the same height and weight are referred to a standard value for comparison (Valdez et al. 1993). Disadvantages of these indicators are that they are ratios which are not easy to interpret biologically (Bouchard et al. 1990) or to use in statistical analyses (Allison et al. 1995). Furthermore, ratios have been shown to be inappropriate for evaluating changes in fat distribution with weight loss (Bouchard et al. 1990, van der Kooy et al. 1993).

Although an elevated WHR is a powerful predictor of numerous diseases (Björntorp 1993), WHR as a ratio is also not easy to interpret. This ratio combines two circumference measurements: the waist measurement includes visceral organs and abdominal fat, whereas that of the hip reflects fat mass as well as muscle mass and skeletal frame (Molarius and Seidell 1998). The relative size of peripheral muscle provided by hip measurements may contribute independently to ill health (Björntorp 1998), such as to an elevated risk for non-insulin-dependent diabetes, since subjects with a high WHR may be at higher risk not only because of a broad waist but also because of narrow hip circumference (Seidell et al. 1997). In all, WHR is useful in public health work and continues to be a useful research tool in epidemiological studies (Björntorp 1993, Lissner et al. 1998), although its use as a surrogate measure of visceral obesity is not recommended (Rankinen et al. 1999).

Recent evidence suggests that waist circumference alone may be a better indicator of abdominal fat and a predictor of ill health than WHR (Seidell et al. 1988, Pouliot et al. 1994), and it has been recommended as a tool for identifying need for weight management (Lean et al. 1995). Waist circumference is strongly correlated with visceral fat deposits (Lemieux et al. 1996, Han et al. 1997a, Taylor et al. 1998, Rankinen et al. 1999) but only weakly with height (Han et al. 1997a, b). Because it can be easily measured and interpreted, it is useful in clinical and public health practice (Lean et al. 1998, Molarius and Seidell 1998, Vanltallie 1998).

Besides BMI, the measurement of waist circumference seems to be the best candidate for indicating the health risks of obesity (World Health Organization 2000, Seidell et al. 2001); nevertheless, there is a lack of consistency in the selection and use of anthropometric indicators for classification of abdominal fatness (Molarius and Seidell 1998). While weight and height measurements are quite well standardized, waist circumference can be measured in a variety of ways, the best being by use of bone landmarks as references. To date, no agreement exists on a bone landmark to render circumference measurement reliable and reproducible (Seidell et al. 2001).

The most important limitation in using anthropometric indicators for assessing abdominal obesity is, however, the lack of universal threshold values or cut-off points (Seidell et al. 2001). Attempts have been made to derive cut-off points for WHR and waist circumference (*Table 2*), but the definitions of these cut-off points include a large variety of criteria for classification and are based on a limited number of cross-sectional studies. No consensus has been reached about the appropriateness of these different cut-off points (Molarius and Seidell 1998). Furthermore, the use of these indicators for assessing health risk may be population-specific and may depend on other risk factors (Molarius et al. 1999a, World Health Organization 2000).

Table 2. Criteria used to define cut-off points for weight management according to waist-to-hip ratio and waist circumference.

Criteria	Cut-off point		Number of subjects[1]	Age (years)	Reference
	Men	Women			
Waist-to-hip ratio					
Risk of CVD and death	1.00	0.80	792+1462	54 (men) 38-60 (women)	Björntorp 1985
Risk of CVD and death	1.00	0.90	792+1462	54 (men) 38-60 (women)	Bray 1987
Absolute level of visceral fat	0.94	0.88	213+190	≥ 18	Lemieux et al. 1996
Waist circumference					
Cut-off points for BMI and WHR	102 cm	94 cm	990+1216	25-74	Lean et al. 1995
Absolute level of visceral fat	100 cm < 40 years[2] 90 cm > 40 years		213+190	≥ 18	Lemieux et al. 1996

CVD=cardiovascular diseases, BMI=body mass index, WHR=waist-to-hip ratio
[1] men+women
[2] age-specific cut-off points, same for men and women

Adapted from Molarius and Seidell 1998

2.1.3. Other anthropometric measures for assessing obesity

In addition to circumferences, skinfold thicknesses and abdominal diameters, such as a sagittal diameter, have been used as anthropometric measurements in describing fat distribution or fat patterning (van der Kooy and Seidell 1993).

2.2. Prevalence and trends in obesity

This section provides an overview of the prevalence of obesity and its trends in adults in western countries. When comparing data from different cross-sectional surveys, several factors should be kept in mind. Firstly, without a universal definition for obesity, a comparison between different studies is not feasible. Thus, in this overview, obesity is systematically defined as a BMI of 30 kg/m^2 or more according to the WHO international classification (World Health Organization 2000). Secondly, because BMI is known to vary with age (see Section 2.3.1.), the age group under examination will affect results on the prevalence of obesity. Similarly, a lack of standardization of age structure within the population studied may give biased estimates.

Finally, estimates on obesity should be based on measured weight and height because errors in self-reported figures have been shown to result in an underestimation of prevalence (Steward et al. 1987). Furthermore, errors in self-reported height and weight may vary with age and overweight status (Rowland 1990, Kuczmarski et al. 2001). This overview is mainly confined to studies in which data on weight and height are based on measurement. However, a few studies with self-reported anthropometric measures have been mentioned because using these data in further evaluating BMI changes in some populations over time is justified. As far as the author is aware, no studies exist that indicate that reporting bias varies with time.

2.2.1. Obesity in Finland

Epidemiological health surveys, including measurements of weight and height, have been conducted in Finland since the mid-1960s. On the basis of these nation-wide surveys, the prevalence of obesity was 8% in men and 17% in women aged 15 years or older at the end of the 1960s and the early 1970s (Rissanen et al. 1988). Another survey a decade later resulted in obesity prevalences of 11% and 14% for men and women aged 30 years or older, respectively (Reunanen 1990). Weight and height of Finnish adults have also been monitored as part of cardiovascular risk factor surveys, which have been carried out in eastern Finland since the early 1970s. The prevalence of obesity was 11% in men and 22% in women aged 30-59 years in two eastern regions in 1972. Twenty years later, these prevalences were 20-21% in men and 18-22% in women. In the southwestern part of Finland, obesity prevalence was 17% in men and 14% in women in the early 1980s. Ten years later, the prevalence was 16% in these men, similar to the figure for men living in the capital area of Finland. In women, the prevalence was 15% in the southwest and 14% in the capital area in 1992 (Pietinen et al. 1996).

Health behaviour surveys have been conducted annually since 1978. In these surveys, data on weight and height of Finnish adults aged 15-64 years are based on self-reports. According to these data, mean BMIs and the prevalence of obesity seem to have increased especially in men, but also in women, among whom the upward trend tended to level off in the mid-1990s (Puska et al. 1996, Helakorpi et al. 2000).

Thus, data from Finnish surveys suggest that the prevalence of obesity was already high in women in the early 1970s and has not increased much during the past decades. In men, the obesity prevalence used to be lower than in women but is continuously increasing.

2.2.2. Obesity elsewhere in Europe

WHO MONICA study

The most comprehensive data on the prevalence of obesity have been collected during the WHO MONICA Project (WHO 1988). This project, designed to monitor trends and determinants in cardiovascular disease, comprises 54 populations in 26 countries situated mainly in Europe. These risk factor surveys were performed in two to three independent cross-sectional surveys at five-year intervals, of which the first was carried out in most countries in the early 1980s and the last one in the early 1990s. The surveys included random samples of at least 200 subjects of each gender and ten-year age group for the age range from 35 to 64 years, and optionally for subjects aged 25-34 years.

In many countries, only one or some of the regions were included in the surveys, and therefore, the MONICA populations may not necessarily be representative of the countries. However, these data are invaluable for comparison between populations, because the data on height and weight have been measured with an identical protocol over the same time periods, if not exactly the same years. In addition, data are age-standardized. In this overview, data on the prevalence of obesity in subjects aged 35-64 years are presented only from those European MONICA populations where a ten-year trend was available (http://www.ktl.fi/ publications/monica). Data from the United States were also included.

In men, the least obese populations (around 10%) were found in Sweden, Denmark, Spain and the Toulouse region in France, whereas in Strasbourg, France, more than 20% of the population was obese (*Figure 1)*. In rural Germany, Switzerland/Ticino, the Czech Republic and Lithuania/Kaunas, the prevalence of obesity exceeded 20%. In the 1990s, every fifth man in Finland and Warsaw were obese. Within ten years, obesity prevalence has increased in most populations.

The increase was especially steep in the United Kingdom/Glasgow and in the United States/Stanford, where the prevalences of obesity doubled. In contrast to the majority of populations, the prevalence of obesity decreased in Russia/Moscow and Switzerland/Ticino.

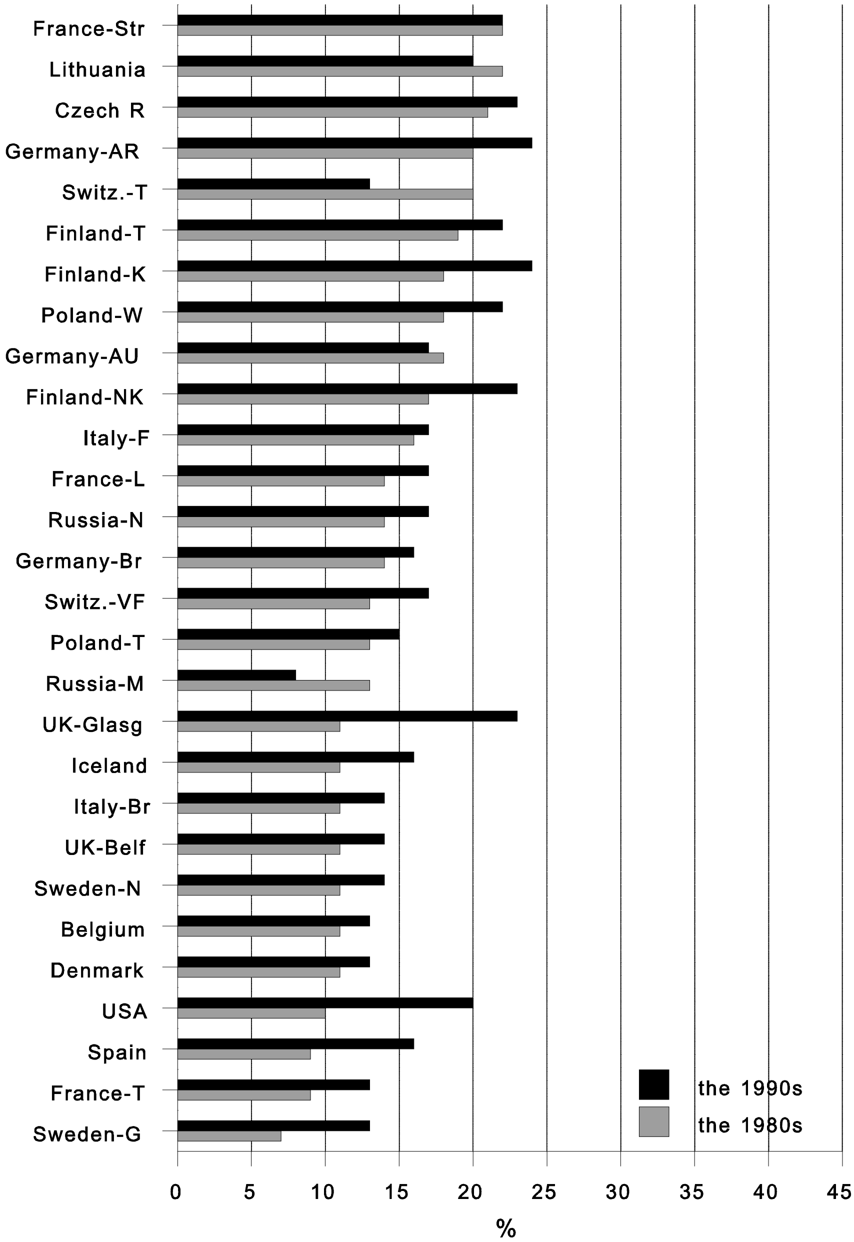

Figure 1. Prevalence of obesity (BMI ≥ 30 kg/m^2) in men in the WHO MONICA populations at baseline (in the early 1980s) and in the survey ten years later (early 1990s).

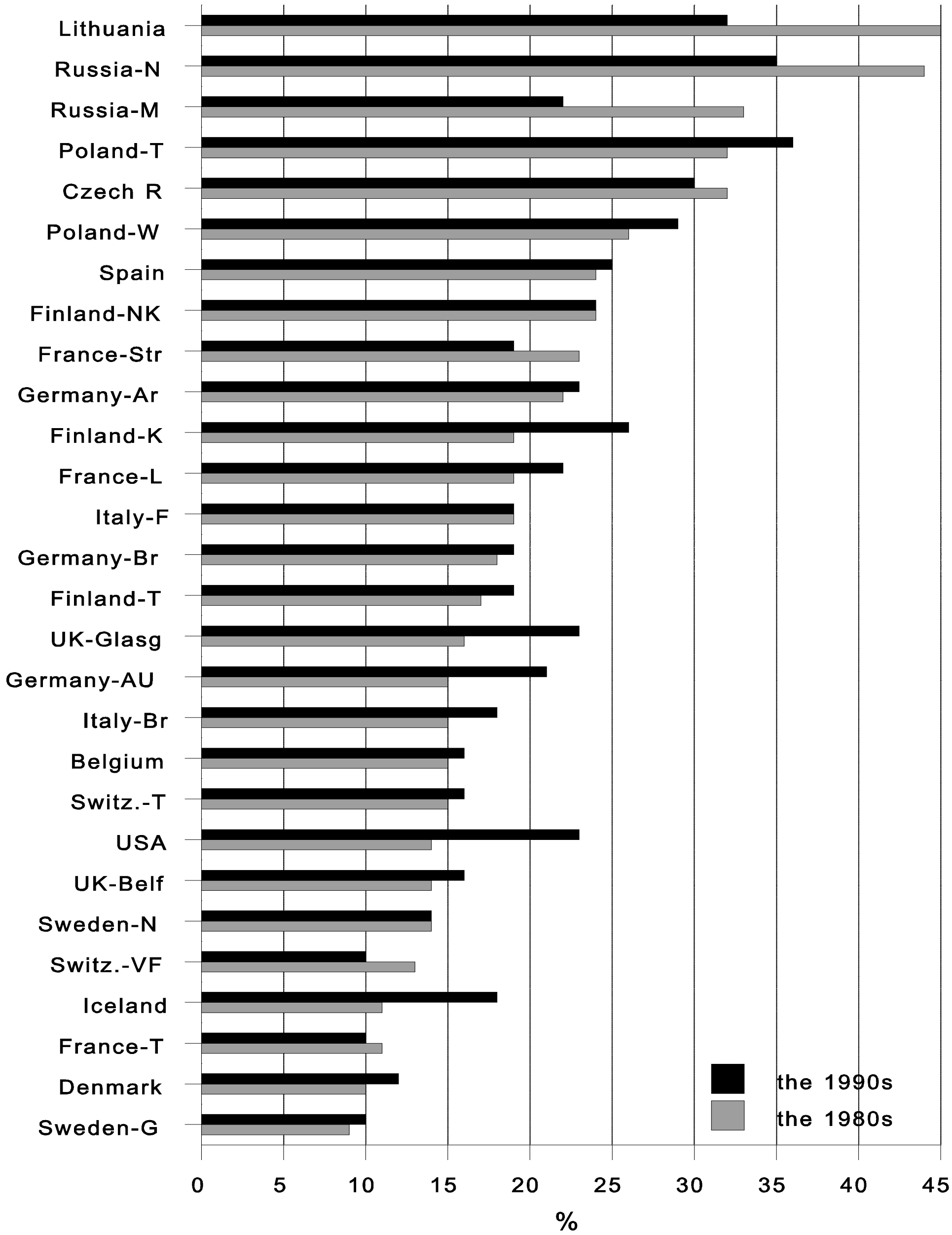

Figure 2. Prevalence of obesity (BMI ≥ 30 kg/m^2) in women in the WHO MONICA populations at baseline (in the early 1980s) and in the survey ten years later (early 1990s). Study populations: Belgium=Ghent-Charleroi,Czech R=Czech Republic, Denmark= Copenhagen, Finland-K=Kuopio, Finland-NK=North Karelia, Finland-T =Turku-Loimaa, France-L=Lille, France-Str=Strasbourg, France-T=Toulouse, Germany-AR= Augsburg rural, Germany-AU=Augsburg urban, Germany-Br=Bremen, Iceland=entire country, Italy-Br=Briaza, Italy-F= Friuli, Lithuania=Kaunas, Poland-T=Tarnobrzeg Voivodship, Poland-W=Warsaw, Russia/M= Moscow, Russia/N=Novosibirsk, Spain=Catalonia, Sweden-G=Gothenburg, Sweden-N=Northern Sweden, Switz.T=Ticino, Switz.-VF=Vaud-Fribourg, UK-Belf=the United Kingdom/Belfast, UK-Glasg=the United Kingdom/Glasgow, USA=the United States/Stanford.

In women, as well, the prevalence of obesity was low (around 10%) in the Nordic countries, with the exception of Finland (*Figure 2*). In Switzerland, France/Toulouse, Italy/Brianza, the United Kingdom/Belfast and the United States, the prevalence of obesity was 15% or less, whereas in most of the eastern European populations it was at least double that of the 1980s. As in men, the most prominent increase in women within the same ten-year period was found in Stanford (the United States) and Glasgow (the United Kingdom). In Iceland, the prevalence of obesity increased remarkably as well, while in Lithuania and Russia it decreased. Overall, a tendency of increasing obesity prevalence was observed in women. Both the prevalence of obesity and its ten-year change varied across the populations more in women than in men.

Other studies in Europe

EURALIM (EURope ALIMentation) is a collaborative study aimed at determining and describing the extent to which non-uniform data can be pooled in a common database for international comparisons. Thus, EURALIM has used a harmonization approach to compare data from seven population-based, locally run studies with somewhat different designs in six countries (France, Italy, the Netherlands, Spain, Switzerland, and the UK). Estimates on the prevalence of obesity were analysed from a database including subjects aged from 40 to 59 years (total 18 381 women and 12 908 men) (Beer-Borst et al. 2000). Based on these data collected between 1992 and 1996, the prevalence of obesity varied from 8% in France to 20% in Italy in men, and from 7% to 37% in women, respectively (*Table 3*). The authors suggest that these international differences may be partly explained by different study designs (Beer-Borst et al. 2000). It should also be noted that most of the populations were from urban regions, but the one with the highest prevalence of obesity was a rural female population in Italy. However, this variation across countries was of the same magnitude as that observed in the WHO MONICA Project (see *Figures 1 and 2*).

When examining the results from other surveys presented in *Table 3*, it should be taken into account that age ranges vary across the surveys, and thus, the results may not be comparable. Evaluating changes in the prevalence of obesity over time based on these surveys is not simple either because weight and height have been monitored regularly in only a few cross-sectional population surveys other than the WHO MONICA Project. Part of the data summarized in this table includes surveys carried out according to the WHO MONICA protocol, and thus, has already been presented in *Figures 1* and *2*. These results were repeated to provide more detailed information, including references.

Data from these surveys suggest that the prevalence of obesity has either remained at a high level or, more often, increased during the last decade (Seidell 1995c). Data from the United Kingdom, in particular, have shown an increase with an extraordinarily steep shift: from 7% to 17% in men and from 12% to 19% in women over a ten-year period (Prentice and Jebb 1995, Seidell 2001).

Results based on self-reported data further support the increasing prevalence of obesity in Europe. Recent cross-sectional surveys of representative samples of the Spanish population aged 25-64 showed that the prevalence of obesity has increased from 8% to 12% in men and from 9% to 12% in women between 1987 and 1997 (Gutierréz-Fisac et al. 2000). In Sweden, a Survey of Living Conditions has been conducted annually since the mid-1970s. Recently, data on weights and heights from surveys carried out in 1980/81, 1988/89 and 1996/97 were reported with the conclusion that the prevalence of obesity among Swedes (aged 16-84 years) had increased significantly from 9% to 12% in women and from 7% to 10% in men over this 16-year period. Self-reported values were adjusted to estimate gender-specific obesity prevalences (Lissner et al. 2000).

Table 3. Prevalence of obesity (%, BMI ≥ 30 kg/m^2) and its trends in selected European countries.

Country (region)	Date[1]	Age (years)	M[2]	W[2]	Reference
The Netherlands	1990-92	40-59	12	14	EURALIM Project:
France	1995-96		8	7	Beer-Borst et al.
Italy (Naples)	1993-96		-	19	2000
Italy (Latina)	1993-96		20	37	
Switzerland (Geneva)	1993-96		11	9	
UK (Belfast)	1991-92		15	16	
Spain (Catalonia)	1992		11	22	
United Kingdom	1987/88	≥16	7	12	Seidell 2001
	1993		13	16	
	1994		14	17	
	1995		15	17	
	1996		16	18	
	1997		17	19	
Belgium (Flanders, Brussels)	1994	18-64	11	10	Moens et al. 1999
Belgium Entire country	1977-78	40-54	9	-	Stam-Moraga et al.
Entire country	1979-84		13	-	1998
Charleroi, Gent	1986-91		16	-	
North Belgium	1992-93		15	-	
The Netherlands	1987-91	20-59	7	9	Seidell et al. 1995
Germany	1982-84	25-64	14	23	Heinemann et al.
(former East-Germany)[3]	1987-89		14	21	1998
	1991-94		13	21	
Germany	1984-86	25-69	15	17	Hoffmeister et al.
(former West-Germany)	1990-91		17	19	1994
Switzerland	1984-85	25-74	11	11	Wietlisbach et al.
(Vaud-Fribourg)[3]	1988-89		11	11	1997
	1992-93		15	10	

Table 3. continues.

Country (region)	**Date[1]**	**Age (years)**	**M[2]**	**W[2]**	**Reference**
Spain (Catalunya, the Basque County, Madrid, Valencia)	1990-94	25-60	12	15	Aranceta et al. 2001
Denmark (Copenhagen) [3]	1982 1992	30-60	10 13	9 11	Heitmann 2000
Sweden (Malmö)	1994-96	45-73	-	13	Lahman et al. 2000b
Sweden (Gothenburg)	1963 1994	50	6 11	- -	Rosengren et al. 2000

[1] Year of data collection
[2] M=men, W=women, % prevalence of obesity
[3] Part of the WHO MONICA Project

2.2.3. Obesity in countries outside Europe

The prevalence of obesity has also increased in the white population outside Europe (*Table 4*), including countries such as the United States (Flegal et al. 1998), Canada (Macdonald,SM et al. 1997) and Australia (Eckersley 2001). Obesity prevalence, especially the proportion of subjects with a BMI ≥ 35 kg/m^2, remains higher (5% for white men, 10% for white women) in the United States than in other countries (Flegal et al. 1998).

Table 4. Prevalence of obesity (%, BMI ≥ 30 kg/m^2) and its trends in white populations in selected countries outside Europe.

Country (survey)	**Date**[1]	**Age (years)**	**M**[2]	**W**[2]	**Reference**
USA (NHANES II)	1976-78	20-74	12	15	Flegal et al. 1998
(NHANES III)	1988-94		20	22	
Canada (National Survey)	1986-92	18-74	13	14	Macdonald et al. 1997
Australia (capital cities)	1980	25-64	7	7	Eckersley 2001
	1989	25-64	9	11	
	1995	25-64	18	16	
	2000	≥ 25	17	19	
Australia (WHO MONICA)	1986	35-64			Molarius et al. 1997
Newcastle			15	16	
Perth			9	11	
New Zealand	1989	18-64	10	13	Wilson et al. 2001
(National Survey)	1997		15	19	

[1] Year of data collection
[2] M=men, W=women, % prevalence of obesity

2.3. Factors associated with BMI and obesity

Why do people become obese? A convenient answer would be that obesity is a consequence of an energy imbalance where energy intake has exceeded energy expenditure over a considerable period. However, arguing that obesity results from overindulgence of food or lack of physical activity is an oversimplification. Powerful societal and environmental forces influence energy balance and can overwhelm the physiological regulatory mechanisms. An individual's susceptibility to these forces is affected by genetic and other biological factors (World Health Organization 2000). Obesity arises from the interaction between genes, environment and behaviour. As described in the previous section, the prevalence of obesity has increased worldwide during the last few decades, while our genes have hardly changed at all (Gill 1997). The genetic background of most people is likely not equipped to handle the current abundance of food and a sedentary lifestyle (Filozof and Gonzalez 2000). Thus, the environment has been suggested to promote obesity-causing behaviours (Egger and Swinburn 1997, Hill and Peters 1998). Nevertheless, little is known about factors that may explain the obesity epidemic or the large differences between populations in the distribution of BMI and the prevalence of obesity (Seidell and Flegal 1997, World Health Organization 2000).

The following section will give a summary on factors, which have commonly been associated with BMI and obesity in epidemiological studies. The classification of these factors follows the review by Seidell and Flegal (1997). Biological factors, e.g. genetics and the effects of menopause, have not been included in this overview.

2.3.1. Demographic factors: gender, age and ethnicity

Gender

Women generally have a higher prevalence of obesity (BMI ≥ 30 kg/m^2), especially after the age of 50 years, whereas men usually have a higher prevalence of overweight (BMI 25-29.9 kg/m^2) (Flegal et al. 1998, Stam-Moraga et al. 1999). In addition, in most European countries, the prevalence of obesity in women as compared with men varies much more across countries (Seidell 1995b).

Given that the mean BMI in men is not necessarily that different from BMI in women, body composition does vary by gender. Men have more skeletal muscle than women – both in absolute terms and relative to body mass. These differences have been found to be greater in the upper body (Janssen et al. 2000).

Age

A BMI increase with age has been documented in several cross-sectional studies (Rolland-Cachera et al. 1991, Boyle et al. 1994, Seidell et al. 1995, Flegal et al. 1998). The older the subjects, the higher the mean BMI and the prevalence of obesity in both men and women, at least up to the age of 50-60 years (Rolland-Cachera et al. 1991, Seidell 1995b, Seidell et al. 1995). The BMI increase with age in women tends to continue longer than in men (Seidell et al. 1995, Stam-Moraga et al. 1999). In fact, in a Swiss population, BMI in men did not vary at all across age groups (Morabia et al. 1997).

In addition to cross-sectional studies, the few longitudinal studies support the finding that people generally gain weight as they become older, with 60 years of age typically marking a turning-point (Rissanen et al. 1988, Williamson et al. 1990, Lewis et al. 1997, Guo et al. 1999, Heitmann and Garby 1999). These studies have shown that the most prominent increase in body weight usually takes place in early adulthood. For example, in a Danish study, the average annual weight change was 0.7-0.8 kg in men and 1.0-1.1 kg in women aged 30-40 years in a ten-year follow-up. For men and women aged 50-60 years, the respective weight increases were 0.4 kg and 0.5-0.6 kg (Heitmann and Garby 1999).

Independent of gender, ageing is associated with a decrease in skeletal muscle. The absolute amount of skeletal muscle is preserved until an age of 50, after which it usually decreases rapidly, especially in the lower body (Janssen et al. 2000). The rate of loss is, however, influenced by changes in body weight (Forbes 1999). Generally, skeletal muscle relative to body mass starts to decrease during the third decade, since weight gain with age is predominantly composed of fat (Janssen et al. 2000).

Ethnicity

The prevalence of obesity has been shown to vary across ethnic groups (Flegal et al. 1998). These differences have been suggested to be partly due to a genetic predisposition for obesity, which becomes apparent especially when individuals are exposed to an affluent lifestyle, such as Pima Indians in Arizona or Australian Aboriginals in an urban environment (World Health Organization 2000)

When assessing the level of obesity and comparing populations based on BMI, the validity of the BMI cut-off points for obesity may differ for different ethnic groups. Although in some studies no differences between BMI and body fat of ethnic groups have been found (Gallagher et al. 1996), the majority of publications together with a meta analysis carried out recently confirm that the relationship between body fat and BMI varies across ethnic groups (Deurenberg et al. 1998). Thus, variations in BMI between ethnic groups should be interpreted with caution (World Health Organization 2000).

Besides the issues of ethnic groups possibly having different genetic backgrounds or methodological limitations, variation in BMI between different ethnic groups may be a question of differences in body image, ideal weight and weight concern. However, research examining the relationship between ethnicity and aspects of weight concern has produced contradictory results (Ogden and Chanana 1998). Some studies have shown that body dissatisfaction and dieting behaviour are more common among white than black or Asian women (Burke et al. 1992, Smith et al. 1999, Miller et al. 2000), whereas other studies have revealed the opposite (Hill and Bhatti 1995, Striegel-Moore et al. 1995).

From the Finnish point of view, examples of Pima Indians and ethnical questions overall may seem somewhat distant since the Finnish population is ethnically quite homogeneous. Keeping in mind, however, the increasing number of immigrants, this issue may be relevant in future assessments of obesity prevalence in Finland. A Swedish study recently showed that obesity was less prevalent among original Swedish people than immigrants from eastern Europe or Finland who had been in Sweden for years (Lahman et al. 2000a). Nonetheless, results from these kinds of studies should be interpreted with care because they are prone to confounders such as educational level.

2.3.2. Sociocultural factors: education and family situation

Educational level

The socioeconomic gradient in obesity is amply documented in the literature (Lissner 1997). Especially in women, a strong inverse association between obesity and socioeconomic status (SES), mostly assessed by educational level, has been reported in numerous affluent populations (Sobal and Stunkard 1989, Bennett 1995, Wamala et al. 1997, Rahkonen et al. 1998, Stam-Moraga et al.

1999, Wardle and Griffith 2001). For instance, almost all populations in the WHO MONICA study showed that education was inversely associated with BMI in women, the difference between the highest and lowest educational tertiles ranging from –3.3 to 0.4 kg/m^2. This association was less consistent in men, although in about half of the populations in the 1990s an inverse association was observed. In most of the other populations, no association between education and BMI was found. The results suggested a positive association only in some eastern and central European populations (Molarius et al. 2000). In a recent British study, men with a low SES had the lowest BMI (Wardle and Griffith 2001). By contrast, many studies have found that men with a low SES have a higher BMI than men with a higher SES (Sobal and Stunkard 1989, Bennett 1995, Stam-Moraga et al. 1999), although the pattern for men is less clear than for women (Sobal and Stunkard 1989, Pietinen et al. 1996, Lissner 1997, Stam-Moraga et al. 1999).

These large BMI differences by SES in women have been suggested to be due to a higher frequency of weight monitoring, a lower threshold for defining themselves as overweight and more eagerness in weight control efforts among subjects with a high SES (Wardle and Griffith 2001). In a Swedish study, more than half of the association between low SES and obesity was explained by reproductive history, unhealthy dietary habits and psychosocial stress (Wamala et al. 1997). Thus, some of the SES differences in BMI may be accounted for by demographic and behavioural factors. Similarly, SES may confound associations observed between health behaviour and BMI. Overall, complex interactions likely underlie these phenomena.

The consistency of these SES-obesity associations over time has been examined in a few cross-sectional studies, with contradictory results. Differences between educational groups were observed to increase in about two-thirds of the WHO MONICA populations over ten years (Molarius et al. 2000), whereas no indication of an increase was detected in a German (Helmert et al. 1995) or a Swedish population (Lissner et al. 2000). In addition, these secular trends have been shown to vary by gender such that BMI trends in different educational groups diverge more for women than for men (Bennett 1995, Gutiérrez-Fisac et al. 1996, Peltonen et al. 1998).

Results from longitudinal studies are controversial as well. In Sweden, less educated men were shown to gain less weight than men with higher education (Sundquist and Johansson 1998), whereas in a Finnish study, subjects with low education were more likely to gain weight than well-educated men and women during a five-year period (Rissanen et al. 1991). Overall, associations between SES and obesity, and the consistency of this association appear to vary across countries, perhaps on the basis of affluence of the country (Molarius et al. 2000)

Marital status

Marital status has been found to be associated with BMI and obesity, although this relationship is not well established. Several (Kahn et al. 1991, Rosmond et al. 1996), but not all (Tavani et al. 1994, Wamala et al. 1997) cross-sectional studies have shown married or cohabiting subjects to have a higher BMI than subjects living alone. A study carried out in the European Union suggests single subjects (data on men and women analysed together) are less likely to be obese than married or previously married subjects (Martínez et al. 1999). Furthermore, in a US study, married men were found to more likely be obese than never married or previously married men. In women, however, marital status was not associated with obesity (Sobal et al. 1992). In contrast, in Belgium and Spain, married women but not men had a higher BMI compared with single women (Stam-Moraga et al. 1999, Aranceta et al. 2001). Cultural differences, e.g. in traditional gender roles, may explain these inter-country variations.

Overweight tends to increase after marriage. In a few longitudinal studies, the BMI of those who got married during the follow-up period increased more than those retaining the same marital status as at the beginning of the study (Kahn et al. 1991, Rissanen et al. 1991, Sundquist and Johansson 1998). In a US study, men getting married or remaining unmarried were shown to be more likely to gain weight over a ten-year period than men who were consistently married. However, a marriage ending (divorced, widowed) was associated with weight loss (Kahn and Williamson 1990).

Number of children

Childbearing has been suggested to be a contributor to obesity in women, with pregnancy belonging to the vulnerable period for development of obesity (World Health Organization 2000). Parity has been observed to be positively associated with BMI in several (Heliövaara and Aromaa 1981, Tavani et al. 1994, Björkelund et al. 1996), but not all (Wamala et al. 1997), cross-sectional studies. In most longitudinal studies as well, parity has been identified as a predictor of weight gain (Rissanen et al. 1991, Brown et al. 1992, Williamson et al. 1994, Lahman et al. 2000b). The average weight gain associated with childbearing appears, however, to be quite modest after controlling for ageing, which has been identified as a much stronger determinant of BMI increase (Brown et al. 1992, Smith et al. 1994, Williamson et al. 1994).

The effect of childbearing on body weight may be due to environmental factors rather than being purely biological. This is supported by findings in which post-partum weight retention has been shown to be more affected by a change in lifestyle during and especially after pregnancy than before pregnancy, both in the general population (Öhlin and Rössner 1994) and in obese women (Rössner and Öhlin 1995).

The number of children may not have an effect on women’s weight alone, since in a study carried out in England and Scotland, having several children in the family was associated with overweight in both parents (Rona and Morris 1982). This finding is supported by another study showing that the number of household members aged under 20 years was associated with obesity both in men and women (Sobal et al. 1992).

2.3.3. Dietary intake, physical activity, alcohol consumption and smoking

This section examines dietary intake and physical activity in relation to BMI and obesity, regarding them as behavioural factors rather than sources of energy intake or consumption. It is important to note that weight changes observed in populations over time are generally so small that they are unlikely to be detected by existing methods for measuring energy expenditure and energy intake in populations (Seidell 1997, Heitmann and Garby 1999). Alcohol consumption and smoking habits are also discussed as lifestyle factors.

Food choices and dietary intake

Nutrition is of critical importance in establishing a positive energy balance. Of the nutritional factors related to obesity, dietary fat intake is widely believed to be the primary determinant of body fat (Bray and Popkin 1998). High-fat diets have been suggested to promote obesity by increasing energy intake, further increasing the likelihood of a positive energy balance and weight gain (Ravussin and Tataranni 1997, Hill et al. 2000). This has been proposed to be due to the greater flavour and palatability of high-fat foods and their high-energy density (Poppitt 1995) but weak effect on satiation (Blundell and Macdiarmid 1997, Rolls 2000).

From epidemiological studies, however, evidence for a high-fat diet promoting a positive energy balance and development of obesity is not definitive (Lissner and Heitmann 1995, Seidell 1998). As reviewed by Lissner and Heitmann (1995), most of the cross-sectional studies have shown a positive association between the percentage of dietary fat and BMI. Some recent studies support this finding (Tremblay et al. 1995, Doucet et al. 1998), although in other studies this association has been found in men only (Macdiarmid et al. 1996, Blokstra et al. 1999, Stam-Moraga et al. 1999). Interestingly, an inverse association was reported in a study that showed that women with a higher BMI reported a lower fat intake than women with a lower BMI (Hjartåker and Lund 1998).

Results from prospective studies on dietary fat intake and weight gain are also inconsistent (Lissner and Heitmann 1995, Williamson 1996, Seidell 1998). A positive association between dietary fat intake and weight gain has been observed in many (Klesges et al. 1992, Coakley et al. 1998, Sherwood et al. 2000), but not all (Colditz et al. 1990, Jorgensen et al. 1995) studies. The association has occationally been found only in men (Kant et al. 1995) or among women who were genetically predisposed to obesity (Heitmann et al. 1995). In Rissanen et al. (1991), women with dietary fat intake in the highest quintile were more likely to gain weight than women with lower fat intake. No association was found among men. It is noteworthy, however, that fat intake was not adjusted for energy intake, and similar associations were also observed for other macronutrients. Bild et al. (1996) also observed a low baseline fat intake to be associated with weight loss in young women but not in men.

The inconsistency of associations between fat intake and obesity is comprehensible when the limitations of epidemiological measures are kept in mind. These limitations include the under-reporting of fat intake by obese subjects as well as obesity leading to dieting behaviour, which in turn may result in lower fat intake among those who attempt to lose weight (Seidell 1998).

In all, the debate about the role of high-fat diets in promoting obesity has gained much attention. While ample research has been suggested to provide strong evidence that consumption of a high-fat diet increases the likelihood of obesity (Bray and Popkin 1998, Hill et al. 2000), it has also been concluded that high-fat diets do not appear to be the primary cause of high obesity prevalence (Willet 1998), and that conclusive evidence of dietary fat intake playing a larger role than other macronutrients in promoting development of obesity is lacking (Seidell 1998).

The importance of energy density in promoting obesity has been emphasized recently (Rolls 2000). The high-energy density of a high-fat diet rather than its fat content has been proposed as a reason for overconsumption of foods high in fat (Poppitt and Prentice 1996, Bell et al. 1998). Independently of fat content, energy density may be a strong determinant of energy intake, as was shown in a recent study in which high- and low-fat diets matched for energy density, palatability and fibre resulted in similar energy intakes over nine days (McCrory et al. 2000). Energy density, not fat content, of the foods was shown to affect total energy intake at meals in both lean and obese women (Rolls et al. 1999). Until now, limited data have been available for comparing energy densities of diets consumed by people with different BMIs (Poppitt and Prentice 1996). In one study, obese subjects appeared to consume a diet higher in energy density compared with lean subjects (Cox et al. 1999), whereas in another study, energy density was found to be related to BMI in men but not in women (Marti-Henneberg et al. 1999). In practice, however, energy-dense diets also tend to have high-fat content (Poppitt 1995). Occasionally, some commercial low-fat foods may include sugars and other energy-yielding substances, thus remaining high in energy and having high-energy density. In these cases, lower in fat does not mean lower in energy. Thus, a low-fat message may give people a false license to overeat (Rolls and Miller 1997).

Dietary factors that are less frequently examined as potential determinants of overeating include fibre, glycemic index and dietary variety (Roberts and Heyman 2000). Intake of fibre has been observed to be inversely associated with BMI in some cross-sectional surveys (Appleby et al. 1998, Delvaux et al. 1999). In one study, men but not women with a high BMI were reported to have a low fibre intake (Slattery et al. 1992), whereas another study showed that women with a high BMI reported higher fibre intake than women with a low BMI (Hjartåker and

Lund 1998). The roles of glycemic index and dietary variety in energy balance and thus in promoting obesity remain controversial (McCrory et al. 1999, 2000, Ludwig 2000).

Overall, population-based studies on diet and obesity have reported inconsistent results, which have been attributed to several factors including weaknesses in study design, methodological errors in estimating energy and nutrient intakes, and confounding factors (Lissner and Heitmann 1995, Seidell 1998). Regarding studies on energy density, for example, these values may differ markedly depending on the method of calculating energy density (Cox and Mela 2000). Furthermore, underreporting of dietary intake, which has been shown to be BMI-dependent, may distort the relationship between dietary intake and obesity. Several studies have observed that obese subjects tend to underreport their dietary intake more than others (Heitmann 1993, Lafay et al. 1997, Heerstrass et al. 1998, Johansson et al. 1998, Heitmann et al. 2000). Some reports also suggest that foods high in fat and/or carbohydrates may be more commonly underreported (Heitmann and Lissner 1995).

To summarize, numerous dietary factors have been suggested to be associated with obesity. To date, however, there is no conclusive evidence from epidemiological studies that any special composition diet promotes the development of obesity more than other diets.

Physical activity

Physical activity has three main components: occupational work, household chores and leisure-time physical activity (World Health Organization 2000). This overview is focused mainly on the latter component due to the shortage of epidemiological studies reporting on the role of work and household activities in obesity.

Physical activity has been shown to be inversely associated with BMI in numerous cross-sectional studies (Gutiérrez-Fisac et al. 1996, Rosmond et al. 1996, Blokstra et al. 1999, Martínez-González et al. 1999, Stam-Moraga et al. 1999), and obese subjects have been observed to be physically less active than the non-obese (Miller et al. 1990, Cooper et al. 2000). However, in some studies, no association between physical activity and BMI has been found (Seidell et al. 1991, Tremblay et al. 1995), or an inverse association has been observed only in women (Slattery et al. 1992, Fentem and Mockett 1998).

In an Australian study, physical activity was not directly associated with being overweight. Instead, regardless of physical activity pattern, subjects who reported watching TV more than four hours daily were twice as likely to be overweight than subjects watching TV less than one hour per day (Salmon et al. 2000). Hours of television viewing was also observed to be positively associated with BMI in Swedish men (Rosmond et al. 1996) and US women but not men (Jeffery and French 1998). Similarly, subjects spending more than 35 hours a week of their leisure time sitting down were 1.6 times more likely to be obese than subjects who spent less than 15 hours per week sitting down (Martínez-González et al. 1999).

Prospective studies have produced more inconsistent estimates of the effect of physical activity on weight gain (Williamson 1996, Fogelholm and Kukkonen-Harjula 2000). However, most studies with data on physical activity collected at the end of the follow-up have shown an inverse association between physical activity and weight gain (Rissanen et al. 1991, Williamson et al. 1993, Haapanen et al. 1997, Barefoot et al. 1998, Delvaux et al. 1999). When data on physical activity were collected at baseline, the pattern was less clear. In some studies, an inverse association between baseline physical activity level and weight gain has been observed in men only (Haapanen et al. 1997), or no association has been found in men or in women (Williamson et al. 1993, Parker et al. 1997). In contrast, in some studies, women who reported higher levels of activity (Owens et al. 1992) or higher leisure activity and work activity (Klesges et al. 1992) have been shown to have less weight gain over time. In men, higher baseline sports activity was surprisingly associated with increased weight gain (Klesges et al. 1992). In addition, television viewing has not been shown to predict changes in BMI (Crawford et al. 1999).

By using data from both baseline and follow-up, numerous studies have shown that those who became more active gained less weight than those remaining inactive (Owens et al. 1992, Williamson et al. 1993, French et al. 1994, Taylor et al. 1994, Haapanen et al. 1997, Coakley et al. 1998), and those who became inactive had a larger increase in BMI than those who remained physically active (Haapanen et al. 1997, Sundquist and Johansson 1998, Sherwood et al. 2000). Furthermore, in a US study, a decrease in work activity appeared to be associated with higher weight gain, but only in women (Klesges et al. 1992).

Studies on physical activity and body weight suffer, however, from similar methodological problems as studies on dietary intake. In epidemiological studies, physical activity is often assessed with questionnaires rather than for example accelerometers, giving only a crude estimate on habitual physical activity (Wareham and Rennie 1998). Thus, confounding, biased reporting and measurement error make it difficult to interpret results. In recent reviews, habitual physical activity has been concluded to play an important role in attenuating age-related weight gain (DiPietro 1999) and maintaining body weight (Fogelholm and Kukkonen-Harjula 2000).

Alcohol consumption

Studies on BMI and alcohol consumption have also yielded inconclusive results. Epidemiological findings regarding the association of alcohol consumption with body weight have been controversial (Macdonald et al. 1993, Jéquier 1999, Westerterp et al. 1999). Out of 38 studies reviewed by Macdonald et al. (1993), an equal number of studies (n=12) showed either a positive or negative association between alcohol consumption and BMI, whereas in 14 studies no correlation was observed. Interestingly, in most of the studies reporting a positive association, this finding was restricted to men, whereas in women, the association has usually been the inverse (Molarius and Seidell 1997, Westerterp et al. 1999, Brunner et al. 2001). It has also been suggested that subjects with moderate alcohol consumption weigh less than non-drinkers and subjects with heavier alcohol consumption, both in men and women (Colditz et al. 1991). Furthermore, weight gain over time has been shown to be greatest for persons with heavy alcohol consumption in some (Rissanen et al. 1991) but not all (Haapanen et al. 1997) studies.

Alcohol is a considerable component of the diet in many countries, providing about 3-9% of daily energy intake (Westerterp et al. 1999). However, its contribution to the total daily energy intake, and further, to energy balance is unclear. In one Finnish study (Männistö et al. 1996a), as in most of the studies reviewed by Westerterp et al. (1999), alcohol seemed to supplement rather than substitute for energy intake derived from food, whereas in another Finnish study, alcohol displaced food-derived daily energy intake in men, but in women, both total daily intake and food-derived energy intake was lower in alcohol consumers than abstainers (Männistö et al. 1997). Furthermore, despite their higher total energy intake, alcohol consumers were observed to have a lower BMI than abstainers in several studies reviewed by Hellerstedt et al. (1990) and Prentice (1995).

Similarly to measuring food intake, measuring alcohol consumption is liable to reporting errors and to being influenced by cultural differences (Caetano 1998, de Vries et al. 1999). However, the reporting errors generally seem to be of a linear nature, and thus, although being unreliable for assessing actual alcohol intake, the ranking of individuals according to their reports has been suggested to be relative stable (de Vries et al. 1999). Another methodological issue worth acknowledging is that abstainers tend to form quite a heterogeneous group. This is because the group of non-drinkers includes both former drinkers and lifetime abstainers with different reasons (health, conviction, etc.) for not drinking (Rehm 1998). In a Canadian study, former alcohol users were more likely to be obese than current and never-consumers (Cairney and Wade 1998). Thus, the findings regarding non-drinkers should be interpreted with caution, especially if the drinking history of the respondents is unavailable.

Smoking habits

Numerous studies have shown that smoking is associated with lower BMI (Albanes et al. 1987, Kromhout et al. 1988, Barrett-Connor and Khaw 1989, Istvan et al. 1992, Molarius et al. 1997). In 20 of the male and 30 of the female populations out of 42 WHO MONICA combined sex populations, regular smokers had lower BMI compared with never-smokers, whereas no population with smokers having higher BMI than never-smokers was observed (Molarius et al. 1997). However, the relationship between smoking and BMI changing from an inverse association to a positive one was reported in the late 1980s in a Finnish study (Marti et al. 1989). Furthermore, in some recent studies, smoking habits have been found not to be related to BMI (Seidell et al. 1991, Slattery et al. 1992, Cairney and Wade 1998). Thus, it seems that the finding of smokers being leaner than non-smokers may not be as clear as earlier, especially in populations with fewer smokers and more ex-smokers (Molarius et al. 1997). In addition, some prospective studies have suggested that smokers gain more weight than non-smokers during the follow-up period (Williamson et al. 1991).

In prospective studies, smoking cessation has been shown to lead to an increase in weight (Rissanen et al. 1991, Williamson et al. 1991, Coakley et al. 1998, O'Hara et al. 1998). In several cross-sectional studies, in turn, ex-smokers have been observed to be heavier than non-smokers in both genders (Chen et al. 1993, Simmons et al. 1996) or in men only (Boyle et al. 1994, Tavani et al. 1994, Molarius and Seidell 1997, Molarius et al. 1997), whereas in other studies no association has been found in either gender (Albanes et al. 1987, Seidell et al. 1991). Although some reports have suggested that the influence of smoking cessation on BMI may diminish with increasing years after smoking cessation (Chen et al. 1993, Mizoue et al. 1998), this finding has not been confirmed in prospective studies (O'Hara et al. 1998).

The association between smoking status and BMI may be modified by social and behavioural factors, the level of education being a strong confounding factor. A study in Finland recently showed that smokers weighed less than never-smokers at the lowest educational level, whereas at the highest level, they weighed more than never-smokers (Laaksonen et al. 1998). This finding regarding men was supported by a study in the Netherlands (Molarius and Seidell 1997).

3. Aims of the study

The purpose of this thesis was to describe changes in body mass index and obesity in Finnish adults as well as to identify possible risk groups with undesirable trends in obesity by assessing associations of BMI and obesity with demographic, socioeconomic and behavioural factors.

The specific objectives of this thesis were as follows:

1. to describe changes in BMI and the prevalence of obesity by age, education (I,II) and occupation (I) during the past few decades,

2. to investigate whether changes in BMI and obesity with age over a 25-year period differ by gender and birth cohort (II),

3. to evaluate changes in waist-to-hip ratio over a ten-year period (III),

4. to examine associations between obesity and lifestyle factors (III, IV), and their consistency over time (IV).

4. Subjects and methods

4.1. Participants

This study is part of the national FINRISK studies (Vartiainen et al. 2000). Six cross-sectional population surveys were carried out to assess the levels of cardiovascular risk factors in two eastern Finnish provinces, North Karelia and Kuopio (*Figure 3*). These surveys were performed at five-year intervals starting in 1972, with the latest being done in 1997. Study II comprises data collected in eastern Finland between these years. In 1982, the surveys were expanded to include a third, southwestern region, the cities of Turku and Loimaa, and their nearby rural communities. Thus, four of the above-mentioned cross-sectional surveys also cover southwestern Finland. Studies I and IV contain data collected in these three regions between 1982 and 1997. Study III, in turn, includes data from these three regions from 1987 onwards, when measurements on waist and hip circumferences became available.

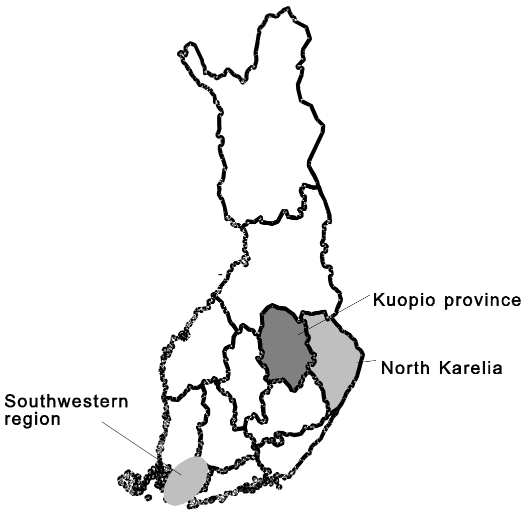

Figure 3. The map of Finland indicating the regions surveyed.

For each survey, a random independent sample was drawn from the population register. These included men and women 25-64 years of age, with the exception of the survey in 1972, in which subjects were born between 1913 and 1947, i.e. were aged 25-59 years. In the two first surveys (1972 and 1977), the samples included 6.6% of the population born between 1913 and 1947. An additional sample of 6.6% of the population born between 1948 and 1952 was drawn from North Karelia only in 1977. Between 1982 and 1997, the samples were stratified according to the WHO MONICA protocol (WHO 1988). Thus, each region, gender and ten-year age strata included at least 250 subjects. Due to a modification of the sampling procedure, the samples in the 1970s were larger than in subsequent surveys. This modification, otherwise, had little effect upon the data since the population of 25-64 -year-olds was equally distributed over each ten-year age group.

Altogether, these surveys included 45 777 subjects, of which 22 200 were men and 23 577 women. The participation rate varied by year from 68% to 87% in men, and from 74% to 90% in women, being at its highest in the early 1970s and at its lowest in the late 1990s. The number of participants and the participation rate in each survey are presented in *Table 5*.

Table 5. Number of participants and participation rates in two regions of eastern Finland combined and in southwestern Finland in each survey year.

	Eastern Finland		**Southwestern Finland**	
Year	**Men**	**Women**	**Men**	**Women**
1972	5055 (86%)	5238 (88%)		
1977	5288 (87%)	5592 (90%)		
1982	3011 (78%)	3029 (84%)	1598 (81%)	1702 (86%)
1987	2243 (75%)	2462 (83%)	731 (76%)	796 (83%)
1992	1425 (72%)	1632 (83%)	749 (75%)	832 (84%)
1997	1417 (71%)	1548 (77%)	683 (68%)	746 (74%)

Studies I,IV

Study III

Study II

To evaluate the effects of sample stratification on the results, the distribution of participants by age and region in relation to the actual population was calculated. These results are presented in *Table 6*.

Table 6. Proportion of participants (%) in relation to the actual population in each region, ten-year age group, and survey year, with men and women assessed separately.

	Age (years)	**1982**	**1987**	**1992**	**1997**
Men					
North Karelia	25-34	2.1	2.2	1.1	1.6
	35-44	3.4	2.6	1.1	1.2
	45-54	4.0	4.0	1.6	1.4
	55-64	5.0	4.5	2.0	2.3
Kuopio	25-34	2.0	0.8	0.9	0.9
	35-44	2.5	0.9	0.8	0.8
	45-54	2.4	1.5	1.3	0.9
	55-64	2.2	1.5	1.5	1.6
Southwestern Finland	25-34	1.9	1.0	1.1	1.0
	35-44	2.8	1.2	1.1	1.2
	45-54	3.6	1.8	1.5	1.2
	55-64	4.6	1.7	2.2	1.9
Women					
North Karelia	25-34	2.9	2.9	1.5	1.7
	35-44	4.2	3.3	1.4	1.4
	45-54	4.4	4.8	2.1	1.7
	55-64	4.3	4.1	2.2	2.1
Kuopio	25-34	1.7	1.0	1.1	1.1
	35-44	2.0	1.1	1.1	1.0
	45-54	2.2	1.6	1.4	1.2
	55-64	2.6	1.4	1.5	1.5
Southwestern Finland	25-34	2.1	1.2	1.2	1.1
	35-44	3.3	1.3	1.4	1.3
	45-54	3.5	1.8	1.6	1.2
	55-64	3.4	1.6	1.8	1.8

In Study III alone, pregnant women (n=145) were excluded from the analyses. Data on pregnancies have been available since 1987.

4.2. Measurements

4.2.1. Anthropometric measurements

In each survey, participants were invited to a health examination at a local health care centre. As of 1982, survey methods followed the WHO MONICA protocol (WHO 1988), which is similar to the study protocol applied in the 1970s.

At the examination, trained study nurses measured participants' weight and height. Measurements were taken with subjects wearing light clothing and no shoes. Weight was measured using balance scales to within 100 g. Height was measured to the nearest 0.5 cm using a height rule taped vertically to a wall. BMI was computed as weight/height^2 (kg/m^2).

Starting in 1987, waist and hip circumferences were measured as well, with participants standing and wearing light clothing. The measurement of waist circumference was taken midway between the lower rib margin and the iliac crest with the participant exhaling gently. Hip circumference was measured at the level of the widest circumference over the greater trochanters. Both waist and hip circumferences were rounded up to the nearest 0.5 cm. Waist-to-hip ratio (WHR) was calculated as waist divided by hip.

4.2.2. Questionnaire

Along with the invitation to the survey, a self-administered questionnaire was sent to the subjects to be completed at home before arrival at the health care centre, where it was checked by the study nurses. It covered questions on socioeconomic factors, medical history, perceived health and lifestyle. In this thesis, we used questions on education (I-IV), occupation (I), perceived health and food choices

(IV), as well as on physical activity, alcohol consumption and smoking history (III,IV).

Educational level was measured as the total number of school years completed. Based on these, subjects were divided into three groups within each birth year to control for improved educational level over time. In other words, the number of school years has increased in Finland over the past few decades such that younger generations have a better opportunity of receiving a higher education.

Occupation was inquired about with seven possible response categories including farmer, blue-collar worker, white-collar worker, student, housewife, pensioner and unemployed.

The number of questions assessing the subject’s diet and food choices varied across the surveys. Bearing in mind secular trends, we used only questions included in all surveys. These questions were of three types. First, the types of food usually consumed were evaluated (milk, cooking fat, fat on bread). Second, the amount of food consumed daily was assessed (glasses of milk and sour milk, slices of bread, cups of coffee and tea). Finally, frequency of consumption of vegetables and sausages was determined.

The measurements for physical activity had several components. In this thesis, we used questions on physical activity both for categorizing subjects according to their physical activity (IV) and for estimating their energy expenditure (III). Estimates on energy expenditure were calculated as described by Fogelholm et al. (1996), using metabolic equivalents (MET), which were calculated as activity energy expenditure divided by resting energy expenditure (Ainsworth et al. 1993).

Occupational activity was originally inquired about with four response categories, from physically very light office work to strenuous work. In Study IV, we combined the first two and the last two groups, defining the work of participants as either physically light or heavy. To evaluate physical activity during travel to and from work, the subjects were asked whether they walked, cycled or used motorized transportation, and the daily duration of this activity.

Leisure-time physical activity was assessed using three questions. In the first question, the type of leisure-time activity was measured with four alternatives varying from no activity to heavy competitive training several times per week. Because of the small number of subjects reporting competitive training, the third and fourth groups were combined in Study IV. Furthermore, weekly time spent on leisure-time physical activity was calculated as the product of frequency times duration, using questions on the frequency of leisure-time activity with six response alternatives and on the duration of these exercise sessions with five alternatives.

Alcohol consumption was assessed with questions on type (beer, wine, liquor), frequency and amount of alcohol consumed during the previous week. Based on this information, an alcohol index was calculated indicating the intake of absolute alcohol in grams per week.

Smoking was assessed using a standard set of questions. Based on the responses, participants were classified into four groups: those who had never smoked (never-smokers), those who had quit smoking at least six months previously (ex-smokers), those who had quit smoking less than six months previously and those currently smoking (smokers). We combined the latter two categories, defining as smokers also those who had quit smoking less than six months previously.

4.3. Statistical methods

In all analyses, data from different regions and from different survey years were pooled such that the year of the survey was used as a factor in the analyses.

Trends in the mean anthropometric measurements were tested by analysis of variance (ANOVA) using the generalized linear model (GLM) procedure of the SAS statistical package with the anthropometric measurement as a dependent variable. Adjustment for region and age was performed. All analyses were done both adjusting and not adjusting for height because the mean height of Finnish adults increased during the study years. Since the results were the same, height was not included in the final models. Secular changes in lifestyle factors were analysed by analysis of variance as well, except for tests of proportions, which were analysed using a chi-square test.

Effects of the sample procedure, i.e. stratification by age and region, on the results of overall prevalences were tested by calculating the prevalence of obesity (BMI∃30 kg/m^2) and the proportions of men and women with WHR exceeding 1.00 and 0.85, respectively, using sampling weights. These weights were derived from the age distribution of the actual population in three survey regions in each survey year. The sample weights were not used in other analyses.

Tests for secular trends in mean BMI or WHR by subgroup (age, education, occupation) were carried out using two models. In the first model, year and variable of interest were included to examine the main effects of these factors. In the second model, an interaction term, including year by the variable of interest, was added to determine whether these trends varied across subgroups. Analyses concerning trends by occupation were adjusted for age. Models for analysing trends by education did not include age because age had been taken into account when the education variable was created.

Changes in the prevalence of obesity or abdominal obesity overall, and by age and education were examined with log-linear models, in which the variable of being obese as a dependent variable, and region, year and age or education with relevant interaction terms as independent variables were included.

Associations between lifestyle factors and obesity were evaluated by logistic regression using odds ratios (OR) and corresponding 95% confidence intervals (95% CI). These analyses were done both using single models with one lifestyle factor in a model at a time controlled for age and education only, and using multivariate models having all the variables with age and education in the same model. Similarly, associations between lifestyle factors and mean BMI were evaluated by linear regression with BMI as a dependent variable.

Data were mostly analysed separately for men and women, except when testing whether phenomena varied across genders. These tests were carried out by including sex and relevant interaction terms by sex in the models.

5. Results

5.1. BMI and prevalence of obesity

Mean BMI increased from 26.3 to 27.1 kg/m^2 ($p<0.001$) in men, and from 25.8 to 26.2 kg/m^2 ($p<0.001$) in women between 1982 and 1997 (I). Simultaneously, the prevalence of obesity (BMI≥30 kg/m^2) increased from 15.4% to 19.8% ($p<0.001$) in men, and from 17.2% to 19.4% ($p=0.006$) in women (I,IV). In addition, the proportion of subjects with a BMI of at least 35 kg/m^2 increased from 2.2% to 4.5% in men, and from 4.7% to 6.6% in women over 15 years (*Figure 4*).

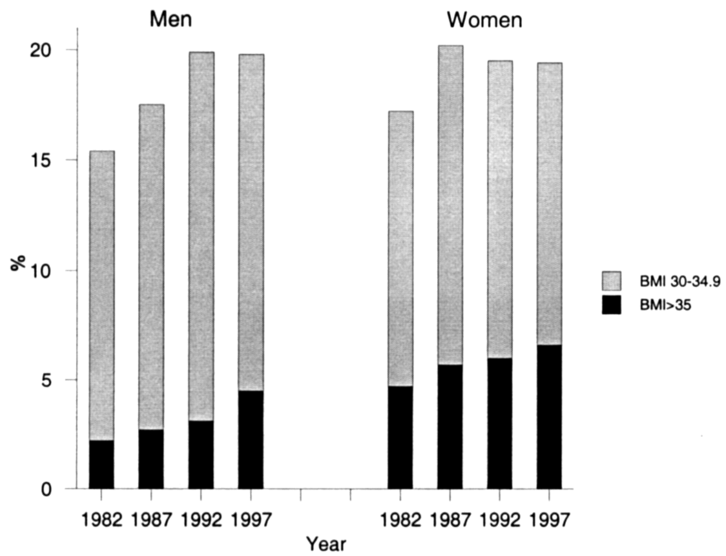

Figure 4. Proportions of men and women with BMI≥30 kg/m^2 between 1982 and 1997 (I).

When the prevalence of obesity for all age groups (25-64 years) was calculated using sampling weights, age-standardization resulted in lower prevalences (*Table 7*).

Table 7. Prevalence of obesity (%, BMI≥30 kg/m^2) in men and women between 1982 and 1997. Crude prevalences and estimates standardized for age-distribution in survey regions.

	Men		Women	
Year	**Crude**	**Age-standardized**	**Crude**	**Age-standardized**
1982	15.4	14.5	17.2	14.8
1987	17.5	15.9	20.2	18.1
1992	19.9	18.0	19.5	17.6
1997	19.8	18.1	19.4	17.8

Using an equation that a difference of one unit of BMI (kg/m^2) corresponds to a weight difference of 3.1 kg for a man of average height (175 cm), and 2.6 kg for a woman of average height (161 cm), subjects with a BMI of at least 30 kg/m^2 were calculated to carry 31 kg more than those whose BMI lies between 18.5 and 25 kg/m^2 (*Table 8*). Subjects with overweight (BMI=25-29.9 kg/m^2) also carry a considerable amount of extra weight (13 kg) compared with normal-weight subjects.

Table 8. Comparisons of body weight in normal-weight (BMI=18.5-24.9 kg/m^2), overweight (BMI=25-29.9 kg/m^2) and obese (BMI≥30 kg/m^2) subjects, and weight difference between overweight/obese subjects and BMI=25 kg/m^2.

	Compared with subjects with BMI=18.5-24.9 kg/m^2		**Compared with BMI=25 kg/m^2**	
	Men	**Women**	**Men**	**Women**
Overweight subjects (BMI=25-29.9 kg/m^2)	+ 13 kg	+ 13 kg	+ 7 kg	+ 6 kg
Obese subjects (BMI≥30 kg/m^2)	+ 31 kg	+ 31 kg	+ 25 kg	+ 24 kg

5.1.1. Age

The most prominent increase in mean BMI over time occurred in the oldest men (I,II). Furthermore, in young adults, both male and female, the mean BMI was significantly higher in 1997 than in 1982 (interaction age by year: $p<0.001$ for men and $p=0.048$ for women). A similar phenomenon was observed in the prevalence of obesity (*Figure 5*).

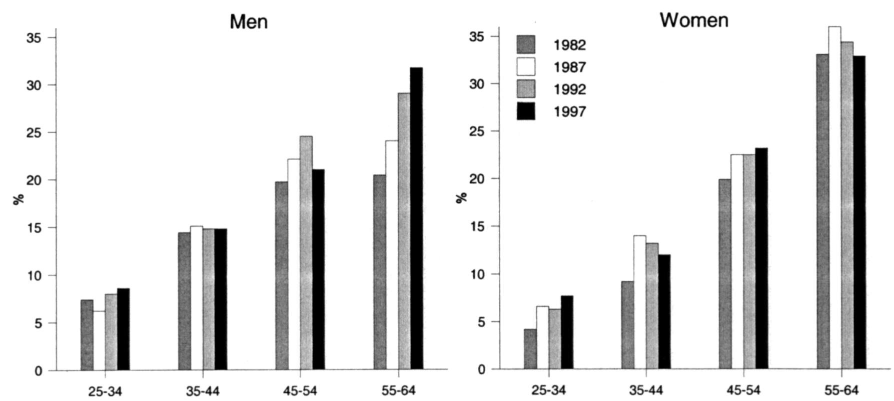

Figure 5. Prevalence of obesity by age in men and women between 1982 and 1997 (I).

Although the increase of both mean BMI and prevalence of obesity over time occurred more strongly in men than women (I), a BMI increase with age was more prominent in women (4.2 kg/m^2 in 25 years) than in men (3.3 kg/m^2 in 25 years). In women, however, weight gain remained unchanged over the 25-year period, whereas in men, the younger the birth cohort, the more prominent the BMI increase with age (II). In men, the corresponding increase was much stronger in the youngest birth cohorts compared with the oldest cohorts. In contrast, the older the age group, the higher the prevalence of obesity in women regardless of the birth cohort (*Figure 6*).

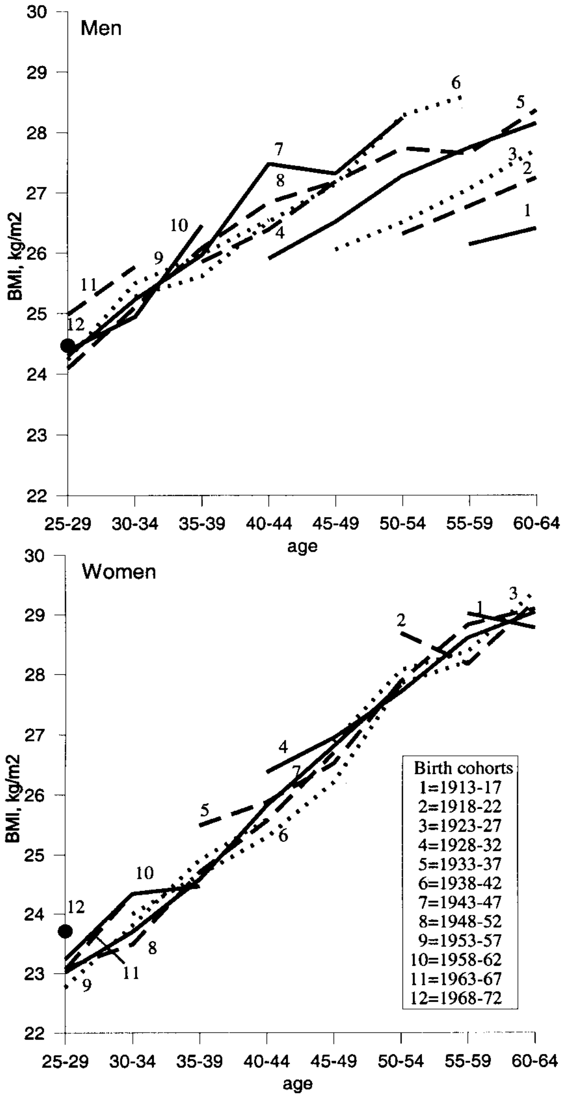

Figure 6. Mean BMI by birth cohort in five-year age groups in men and women (II).

5.1.2. Education

Strong inverse associations of education with mean BMI and obesity ($p<0.001$) were observed in women (I,II). The association between education and mean BMI strengthened over a 15-year period such that the most prominent increase was observed among women with the lowest education (interaction education by year: $p=0.04$). However, this social gradient did not widen in the 1990s, nor did differences between educational groups in the prevalence of obesity over the 15-year period (*Figure 7*). Overall, the mean BMI was 1.5 kg/m^2 greater and the prevalence of obesity was 9%-units higher in women with the lowest education compared with highly educated women in 1997 (I). In addition, after taking into account women's birth year, the BMI difference between the lowest and highest educational groups reached its maximum of 2.5 kg/m^2 in women born between 1933 and 1952 (II).

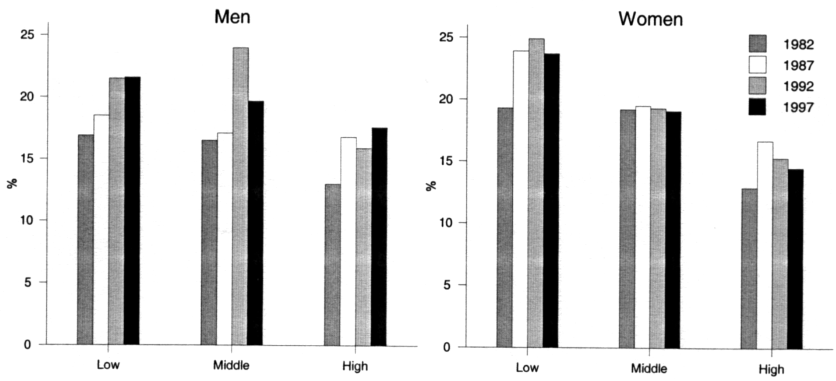

Figure 7. Prevalence of obesity by education in men and women between 1982 and 1997 (I).

In men, neither the BMI increase nor the changes in the prevalence of obesity over time varied across educational groups ($p>0.05$); similar upward trends were observed in all educational groups (I). However, when birth year was taken into account, the lowest increase in mean BMI was observed among the highly educated in the oldest birth cohorts, i.e. in men born between 1913 and 1928 (interaction between birth cohort, education and year: $p=0.03$). The BMI increase over time did not vary across educational groups in younger birth cohorts (II). Although to a lesser extent than in women, the prevalence of obesity also varied across educational groups in men such that it was highest among less educated subjects (*Figure 7*).

5.1.3. Occupation

Changes in mean BMI over the 15-year period varied across occupational groups (interaction occupation by year: p=0.004) in men (*Figure 8*). The most prominent increase was observed in retired men, 1.7 BMI-units in 15 years. The BMI increase was also marked in unemployed men (1.3 units) and in male students (1.2 units). The strongest upward trend in BMI was found among men who were outside the labour force. In contrast, in women BMI changes over time did not differ by occupation (I).

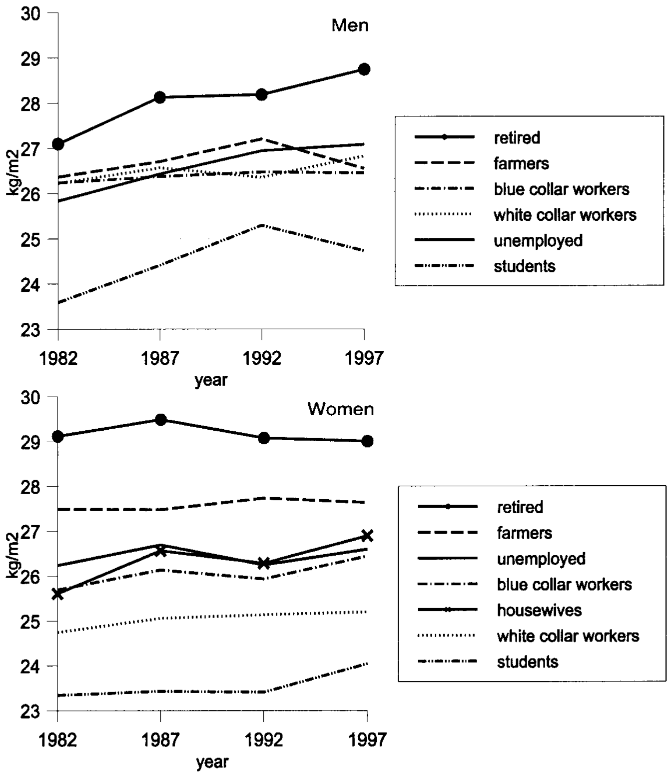

Figure 8. Mean BMI by occupation in men and women between 1982 and 1997 (I).

5.1.4. Lifestyle factors

Leisure-time physical activity and perceived health were inversely associated with obesity both in men and women (*Table 9*). An inverse association was also found

Table 9. Associations of obesity[1] (BMI>30 kg/m^2) with physical activity, food choices and perceived health (IV).

	Men		**Women**	
	I	**II[2]**	**I**	**II[2]**
Work activity: Light (reference, ref.)				
Heavy	0.76	0.70	1.60	1.40
Not working	-	-	1.83	1.29
Walking/cycling to work: <15 min/day (ref.)				
15-44 min/day	0.83	-	0.68	0.71
∃45 min/day	-	-	0.55	0.57
Not working	1.15		1.22	
Activity level at leisure time: Low (ref.)				
Medium	0.78	0.82	0.59	0.65
High	0.42	0.47	0.31	0.39
Leisure-time physical activity: < 20 min/week (ref.)				
20-44 min/week	-	-	-	-
45-150 min/week	0.87	-	0.78	-
>150 min/week	0.75	-	0.69	-
Unable to exercise	1.37	-	1.67	-
Consumption of vegetables: <Daily (ref.)				
Daily	0.79	-	0.75	-
Consumption of sausages: <Once a month (ref.)				
1-2 x month	-	-	-	-
Once a week	1.39	1.43	1.37	1.31
Twice a week	1.66	1.62	1.50	1.29
Almost daily	1.84	1.87	2.33	1.84
Consumption of bread, slices per day	-	-	0.95	0.94
Consumption of milk , glasses per day	1.07	1.12	1.10	1.09
Consumption of sour milk, glasses per day	1.09	1.15	1.12	1.09
Consumption of coffee, cups per day	-	-	1.04	1.03
Consumption of tea, cups per day	-	-	0.93	-
Perceived health: Good (ref.)				
Average	1.66	1.44	1.73	1.55
Poor	2.14	1.87	2.47	1.87

[1]Only significant odd ratios presented (95% CI did not include unity).
[2] I=association based on a single model controlled for age and education,
II=a multivariate model with age, education and all the variables presented in the table.

between daily consumption of vegetables and obesity after adjustment for age and education. This association was, however, attenuated after adjustment for other lifestyle factors. In addition, bread consumption in women and work activity in men had inverse associations with obesity. A positive association was observed between obesity and consumption of sausages, milk and sour milk. In women, heavy work and coffee consumption were also associated with obesity (IV).

Similar results were found when associations between mean BMI and lifestyle factors were investigated. Most associations did not vary across the survey years. However, the inverse association of BMI with physical activity at leisure time, particularly in women, seemed to strengthen (p-values for interaction between year and leisure-time physical activity: 0.0027 for men and 0.0022 for women) over the 15-year period (*Figure 9*), as did perceived health, particularly in men (p-values for interaction between year and perceived health: 0.0001 for men and 0.020 for women).

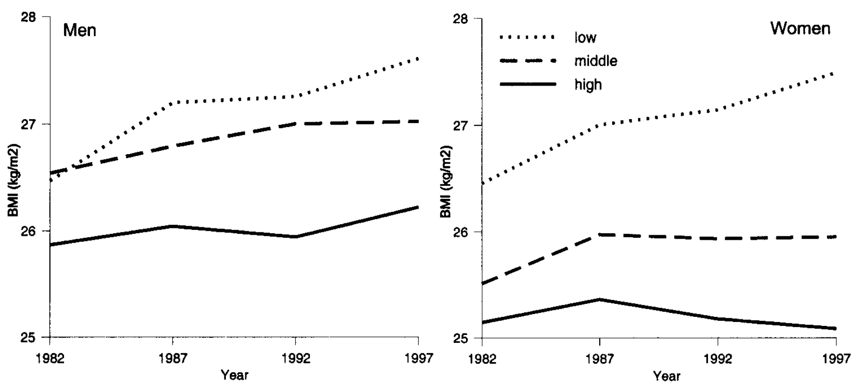

Figure 9. Physical activity level at leisure time and BMI in men and women between 1982 and 1997.

Women preferring skim milk were more likely to be obese (OR 1.25, 95% CI 1.01-1.54) than women who reported not drinking milk at all. Similarly, subjects preferring butter and butter-oil mixture and men using margarine on bread (OR 0.58-0.76 in men and 0.73-0.79 in women) were observed to less likely be obese compared with subjects using no fat on bread (IV).

Alcohol consumption and smoking history were associated with obesity and mean BMI. When compared with subjects having had 1 to 3 portions of alcohol during the previous week, women reporting no alcohol use (OR 1.19, 95% CI 1.04-1.36) and men consuming at least 10 portions (OR 1.33, 95% CI 1.12-1.58) were more likely to be obese. In men, this association became stronger in 15 years (interaction between year and alcohol consumption: p=0.012), while in women it remained stable. Both male and female ex-smokers were more likely (OR 1.65, 95% CI 1.44-1.90 in men and OR 1.30, 95% CI 1.09-1.56 in women) and female smokers less likely (OR 0.79, 95% CI 0.68-0.93) to be obese than never-smokers. In both men and women, the association of smoking history with obesity remained unchanged over the 15-year period, as did that of mean BMI in men. In contrast, the upward trend in mean BMI became stronger in female smokers and ex-smokers (interaction between year and smoking history: p=0.0054), whereas in never-smokers, this trend decreased (IV).

5.2. Waist-to-hip ratio (III)

The mean waist-to-hip ratio (WHR) increased from 0.91 to 0.93 in men, and from 0.78 to 0.80 in women during the ten-year period from 1987 to 1997 ($p<0.0001$). The mean hip circumference simultaneously remained unchanged in both genders, while the mean waist circumference increased from 92.6 to 94.7 cm in men, and from 79.8 to 81.5 cm in women ($p<0.0001$).

The strongest upward trend in WHR occurred in the first five-year period (1987-1992) and then seemed to level off in men, whereas WHR in women continued to increase into the 1990s.

When assessing WHR in normal-weight (BMI<25 kg/m^2), overweight (BMI=25-29.9 kg/m^2) and obese (BMI≥30 kg/m^2) subjects, the mean WHR increased in all groups in both genders over the ten-year period. However, the most prominent increase occurred in obese subjects (p-values for interaction between BMI group and year: 0.0028 for men and 0.0001 for women).

The proportion of men with WHR of 1.00 or more was 8.3% in 1987 and 14.3% in 1997. In women, the proportions of subjects with WHR≥0.85 were 12.6% and 20.1%, respectively. Age-standardized results gave similar estimates on these prevalences (*Table 10).*

Table 10. Proportions (%) of men with waist-to-hip ratio (WHR) ≥1.00 and women with WHR≥0.85 in 1987-1997. Crude prevalences and estimates standardized for age-distribution in survey regions.

	Men		**Women**	
Year	**Crude**	**Age-standardized**	**Crude**	**Age-standardized**
1987	8.3	7.2	12.6	11.0
1992	16.7	14.6	17.6	15.7
1997	14.3	13.2	20.1	18.1

5.2.1. Age

In both genders, the most prominent increase in mean WHR over the ten-year period was observed among those 45 years of age or older (interaction between age and year: $p<0.0001$). In these age groups, the proportion of men with WHR≥1.0 doubled between 1987 and 1992, whereas the increase in the proportion of women with WHR≥0.85 was not as steep but continued steadily to rise over the ten-year period (*Figure 10*).

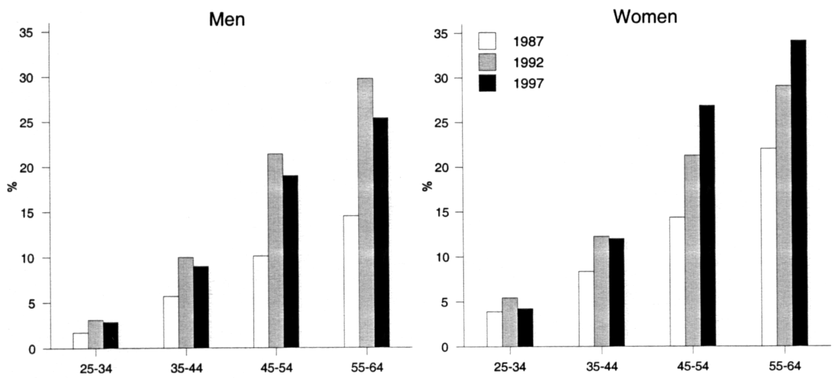

Figure 10. Proportions of men with WHR≥1.0 and women with WHR≥0.85 by age between 1987 and 1997.

5.2.2. Education

The mean WHR increased in all educational groups, the lowest WHR being among those with the highest education (main effect for education: $p<0.0001$ for men and women). Similarly, the proportions of men with WHR exceeding 1.0 and women exceeding 0.85 were significantly greater in 1997 compared with 1987 in all educational groups.

5.2.3 Factors associated with abdominal obesity

Leisure-time physical activity was inversely associated with WHR, whereas a positive association was observed between WHR and alcohol consumption. Furthermore, smokers and ex-smokers were more likely to have a higher WHR than never-smokers (*Table 11*).

Although physical activity, alcohol consumption and smoking history were associated with WHR in both men and women, these lifestyle factors explained only a minor portion of the WHR variation. Instead, age (18% in men, 12% in women) and BMI (33% in men, 25% in women) accounted for most of the variation. However, changes in BMI over time did not explain, at least totally, the increases observed in mean WHR over the ten-year period. In women, a significant increase in WHR was observed despite no concurrent change in mean BMI. In men, in turn, the observed WHR increase was greater than the estimated increase based on the change in BMI.

Table 11. Associations[1] of mean WHR with physical activity, alcohol consumption and smoking history (III).

	Men				Women			
	Model 1[2]		**Model 2[2]**		**Model 1[2]**		**Model 2[2]**	
	β	r^2	β	r^2	β	r^2	β	r^2
Intercept	0.73936		0.53187		0.64364		0.52993	
Age	0.00272	18.2	0.00151	18.2	0.00220	12.3	0.00094	12.3
Education	-0.00407	0.7	-0.00294	0.7	-0.00830	1.9	-0.00368	1.8
BMI	_	_	0.01076	32.8	_	_	0.00704	24.6
Alcohol consumption	0.00331	1.0	0.00215	0.6	0.00402	0.4	0.00471	0.5
Smoking								
Smoker (vs. non-smoker)	0.01017	0.1	0.00928	0.3	0.01130	0.3	0.01173	0.3
Ex-smoker (vs. non-smoker)	0.01570	0.7	0.00385	0.03	0.01306	0.4	0.00851	0.2
Physical activity[3]								
EE at work	0.00357	0.6			0.00792	1.5		
EE when traveling to work	-0.00603	0.1			-0.01682	0.7	-0.00925	0.2
EE at leisure time	-0.00751	0.3	-0.00867	0.4	-0.00444	0.03	-0.00299	0.005
Survey year	0.00844	0.9	0.00722	0.7	0.00735	0.8	0.00715	0.7
Total r^2		22.6		53.8		18.1		40.7

[1] Regression coefficients (β), only significant coefficients are presented ($p<0.05$), n=6651 men and 7200 women. β based on continuous variables were calculated for the following variations: 100 g alcohol per week, and 1 MJ of energy expenditure per day at work, traveling to work, and at leisure time.

[2]Model 1 includes all the variables except BMI presented in the table, Model 2 includes also BMI together with other variables.

[3]EE=energy expenditure

6. Discussion

6.1. Overall changes in BMI and obesity

Upward trends in mean BMI and prevalence of obesity (BMI≥30 kg/m^2) were observed in both men and women. Abdominal obesity, defined as elevated WHR, also showed increasing trends in both genders. This increase took place regardless of BMI changes, suggesting adverse changes in body shape among Finnish adults. The finding of the most prominent upward trend in WHR in obese subjects may further indicate that the proportion of subjects with major obesity-related health risks is increasing.

The upward trends in BMI and prevalence of obesity observed in the 1970s and 1980s in Finnish men (Rissanen et al. 1988, Pietinen et al. 1996) continue to steadily climb, whereas in women, the incline is not as steep. These results also support findings from annual health behaviour surveys of Finnish adults, which show that mean BMI increased in both sexes in the early 1990s (Puska et al. 1996), but then seemed to level off in women (Helakorpi et al. 2000).

Our findings are in agreement with several reports across Europe (Hoffmeister et al. 1994, Seidell et al. 1995, Stam-Moraga et al. 1998, Heitmann 2000, Rosengren et al. 2000) and in the United States (Flegal et al. 1998). Nevertheless, the increases observed were quite modest, especially in women, compared with, for example, the situation in the United Kingdom, where the prevalence of obesity has doubled in ten years (Prentice and Jebb 1995). The finding of greatest import was, however, that the prevalence of subjects with a BMI of more than 35 kg/m^2 reached 4.5% in men, which is almost of the same magnitude as in the white population in the United States (Flegal et al. 1998). The respective prevalences in women were 6.6% in our study and 9.8% in the United States.

Distribution of overall obesity is amply documented in the literature, but besides a few population studies (Seidell et al. 1991, Molarius et al. 1999b, Aranceta et al. 2001), little is known about WHR in populations of different countries not to mention trends in WHR. As far as the author knows, the present study is one of the first describing changes in WHR over time. As a result, comparisons of WHR trends with other western populations are limited to a study carried out in Swedish women, who on average appeared to have a stable BMI but an increased WHR between 1968 and 1993. Thus, these results are in line with the present study, suggesting that Swedish women have also experienced changes in body shape (Lissner et al. 1998).

It is noteworthy that our data covered only eastern and southwestern Finland, hence the samples were not nationally representative. For example, data from the capital area, in which the prevalence of obesity has been shown to be the lowest (Pietinen et al. 1996), were not available over the 15-year period. Furthermore, as the samples were stratified, the age distribution in our data was skewed towards older age groups compared with the age distribution of the population in survey areas. The highest participation rate, which occurred among the oldest women in eastern Finland, especially in the first surveys, further added to the overrepresentation of older subjects. For these reasons, estimates of the mean BMI, WHR and the prevalence of obesity were to some extent overestimated. With regard to trends, the diminishing proportion of older subjects over the years may have diluted the changes observed, especially in women. Overall, trends observed are in agreement with results from annual health behaviour surveys of Finnish adults. These surveys have been carried out with nationally representative samples providing self-reported data on weights and heights (Puska et al. 1996, Helakorpi et al. 2000).

Strengths of our study include a unique database with a large number of participants and repeated surveys conducted with the same, comprehensive study protocol at the same time of the year. Data on weights and heights as well as on waist and hip circumferences were based on measurements taken by specially trained study nurses. Despite a decline in the response rate over the years, participation remained high. The decreasing response rate may have, however, had some effect on results since obesity can be assumed to have been more prevalent among non-participants (Roos 1998).

6.2. The most adverse trends in the extremes of the age range

Young adults appeared to be more obese in the most recent survey compared with earlier years. In agreement with several previous studies (Hoffmeister et al. 1994, Seidell et al. 1995, Peltonen et al. 1998), the increase in BMI was quite pronounced in the youngest age group. However, trends were not as steep as in a recent study in which obesity prevalence had doubled among 30-year-old Danes in ten years (Heitmann 2000).

The most prominent increase in BMI and obesity occurred in the oldest men, whereas obesity in the oldest women remained stable. This gender-specific finding is not supported by other studies; in some studies, the increase in mean BMI or the prevalence of obesity has been shown to be strongest both in the oldest men and women (Hoffmeister et al. 1994, Seidell et al. 1995), whereas in other studies, no increase has been observed for either gender among the oldest subjects (Peltonen et al. 1998).

The most prominent increase in WHR also occurred in the oldest men (>45 years). Interestingly, despite the stable BMI and obesity prevalence among the oldest women, abdominal obesity in this group also appears to be on the rise. This finding is not easy to interpret based on methods used in this study. Keeping in mind the limitations of anthropometric measures in assessing body composition and the suggestion of WHR being a better indicator of body fatness than BMI with ageing (Willett 1998), one explanation could be that excess fatness in older women is actually increasing but, because of changes in body composition, this could not be detected using BMIs. Thus, the plateau in BMI among older women should be interpreted with caution. To assess possible changes in body composition over the years, a different study design with more sophisticated methods is needed.

The BMI range between the youngest and oldest age groups was exceptionally large compared with other studies. Although the prevalence of obesity among the youngest subjects was of the same magnitude as found in some other studies (Hoffmeister et al. 1994, Heitmann 2000), the overall prevalence of obesity was much higher in the present study. This was due to the considerable increase of BMI with age. Interestingly, this increase appeared to be constant in women regardless of birth cohort, whereas in men, younger cohorts seemed to put on more weight with age than older cohorts. However, it is of importance to note that data on BMI of older cohorts at a younger age were lacking. In contrast to a French population, in which a weight increase with age were larger for men than women (Rolland-Cachera et al. 1991), the difference between the age groups with the highest and the lowest BMI remained greater in women, despite a declining gradient between genders over the years.

In all, older male cohorts appeared to be replaced by heavier younger cohorts, as far as our cross-sectional data allowed us to follow the life span of subjects of working age. This finding is supported by a recent Swedish study, in which four male cohorts aged 50 years were investigated between 1963 and 1993. A significant increase was observed both in the mean BMI and the prevalence of obesity over this 30-year period (Rosengren et al. 2000). In contrast, in an Australian study, both male and female participants in a 1989 survey belonged to a heavier population than those in 1980 (Boyle et al. 1994). However, in our study, the youngest women entering the last survey also had a much higher BMI and prevalence of obesity compared with earlier surveys. Although this finding may be due to chance, young adults – both men and women – are definitely one group with an undesirable trend towards obesity.

A possible source of bias in the present study, particularly concerning young women, is that pregnant women could not be removed from the databases of Studies I, II, and IV. In contrast, the database of Study III on waist-to-hip ratios did not include pregnant women because data on pregnancies have only been available since 1987. The proportion of pregnant women was low and remained constant (2-3%) between 1987 and 1997. Hence, we assume that the inclusion of pregnant women in analyses would have had only a minor impact on results.

6.3. Education, occupation and obesity

Not surprisingly, we observed a strong inverse association between educational status and obesity in women, whereas in men, education was a determinant of less importance. This finding is consistent with several other studies (Bennett 1995, Stam-Moraga et al. 1999, Molarius et al. 2000, Wardle and Griffith 2001). Unlike in the majority of WHO MONICA populations (Molarius et al. 2000), this social gradient appears not to have widened in recent years, in line with some other studies (Helmert et al. 1995, Lissner et al. 2000).

As mentioned before, although declining over the survey years, participation rate remained high. However, the decreasing response rate may have influenced the results, especially with regard to associations between education and obesity. Based on analyses of the FINRISK database in 1992 (Roos 1998) and a Danish study (Heitmann and Garby 1999), subjects with low education can be assumed to be less likely to participate in surveys. Thus, as the response rate decreased, particularly among men, possible differences between educational groups may have been diluted. In the youngest age group in 1997, however, the participation rate varied by gender such that it was lower in men with the highest education, whereas in women, it was highest among those with the highest education (Lallukka et al. 2001). Evaluation of this issue in more detail is not possible due to the lack of proper analysis of non-participation in the FINRISK studies over the years.

Trends in BMI varied across occupational groups only in men such that the most prominent BMI increase in 15 years took place among men outside the work force, including the retired, unemployed and students. Most of the students in Finland are younger than 25 years of age, i.e. outside the age range of this study. Hence, our finding is not applicable to students in general. On the other hand, the results concerning retired and unemployed men are of great importance because the number of these subjects is considerable in Finland, especially with the increasing numbers of premature pension beneficiaries.

Our finding of men with heavy work having the lowest increase in BMI over the years suggests that physical activity at work may have an important role in weight management, especially in men. Thus, being out of work may mean a greater decrease in energy expenditure for men than for women. Overall, it has been suggested that changes in energy expenditure in occupational work are more likely to have been greater for men than for women since heavy work for men, in particular, has become less demanding over the years (Fogelholm et al. 1996). We further observed great gender differences in BMI trends in the oldest age group, which may indicate that finding alternative activities to occupational work may be more difficult for men than for women, who are used to working at home (Niemi and Pääkkönen 1990).

Nevertheless, interpretations of our results remain speculative because of the cross-sectional design of this study, which does not allow any causal conclusions to be drawn. We do not know whether men outside the work force were obese before leaving work or whether they became obese afterwards. In a large prospective study, obesity was associated with an increased risk of premature work disability (Rissanen et al. 1990), while in another study, loss of employment was associated with an increased likelihood of gaining weight (Morris et al. 1992).

6.4. Lifestyle factors

As expected on the basis of several reports (Gutiérrez-Fisac et al. 1996, Rosmond et al. 1996, Blokstra et al. 1999, Martínez-González et al. 1999, Stam-Moraga et al. 1999), physical activity at leisure time was inversely associated with BMI and obesity, both in men and women. In addition, the inverse association between the level of physical activity and BMI appeared to strengthen over time, especially in women.

Thus, the suggestion made by Prentice and Jebb (1995) about the increasing importance of physical activity to counteract obesity was clearly supported by our results for women, in whom the associations between BMI and leisure-time physical activity became stronger over the years regardless of the measurement used for assessing physical activity. By contrast, the results for men were not as easy to interpret because the consistency of these associations varied depending on the variable. According to the question querying about the level of physical activity at leisure time, men reporting being sedentary were much heavier in 1997 than in 1982, whereas questions querying about the frequency and duration of leisure-time activity showed no changes in associations over the years.

These inconclusive results concerning physical activity may be due to methodological problems, including biased reporting and measurement error. As in many epidemiological studies (Wareham and Rennie 1998), self-administered questionnaires yield only crude estimates on physical activity. Furthermore, a measurement for everyday household activities was lacking. However, questions on leisure-time physical activity used in the present study were kept constant over the years, thereby allowing comparisons between surveys.

With regard to dietary intake and food habits, we had to be content with crude estimates as well, because assessing dietary habits was also based on self-administered questionnaires. Although the questionnaire has been improved by new questions on food use frequencies over the years, we were only able to use those questions included in all surveys. Fortunately, questions contained within the questionnaire were generally kept unchanged and could be used as indicators for ranking subjects according to food choices. These methods were, however, inadequate for estimating energy or nutrient intake.

As an indicator of healthy or unhealthy food habits, daily vegetable consumption was inversely associated – although not independently of other lifestyle factors - with body weight, whereas sausage eaters were observed to be heavier than others. Our finding of a negative association between bread consumption and body weight supports previous results in which carbohydrate and fibre intake has been shown to be inversely associated with BMI (Slattery et al. 1992, Appleby et al. 1998, Delvaux et al. 1999).

Unexpectedly, persons eating bread without fat or choosing skim milk were more likely to be obese than subjects using any fat on bread or not drinking milk at all. These findings are subject to various interpretations, again because of the cross-sectional design of the study. Since subjects are unlikely to be obese because of omitting fat on bread or preferring skim milk, obese subjects may try to control their weight with these choices. Alternatively, this result may be due to reporting bias, with obese subjects trying to give socially desirable responses (Hebert et al. 1995, Heitmann et al. 2000). These associations could also be purely due to chance, with type of milk or fat used on bread being totally irrelevant in the course of obesity. After all, one should be careful when giving advice on healthy eating to avoid the impression that low-fat products can be used to an unlimited extent (Rolls and Miller 1997). On the other hand, our findings do support the recommendations of daily vegetable and cereal consumption as part of weight control.

In agreement with some studies (Colditz et al. 1991), subjects with moderate alcohol consumption tended to weight less than non-drinkers and subjects with heavier alcohol consumption. However, significance of the associations was dependent on the model used, suggesting that lifestyle factors may be interrelated. Similarly, associations between smoking habits and obesity were unclear. Compared with never-smokers, male smokers were more likely to be obese based on the model adjusted for age and education only, whereas female smokers were less likely to be obese after adjustment for other lifestyle variables. However, our finding of ex-smokers being more likely to be obese than never-smokers is supported by several earlier reports (Chen et al. 1993, Simmons et al. 1996).

Overall, it appears that, unlike in many populations (Istvan et al. 1992, Molarius et al. 1997), smokers in Finland do not weigh less than never-smokers, even among women, which is in agreement with other recent findings (Seidell et al. 1991, Slattery et al. 1992, Cairney and Wade 1998). It should, however, be noted that these associations may be confounded by education (Molarius and Seidell 1997, Laaksonen et al. 1998).

In summary, the present study demonstrated that BMI is determined by behavioural factors. However, the design and methods of the study were inadequate for assessing the causality of these factors in the course of obesity, not to mention their role or effect in the prevention of obesity. More knowledge would be yielded with population-based studies specially designed to examine these associations prospectively. In addition, future studies would profit from a careful control for confounders due to the number of complex interactions underlying these phenomena.

6.5. Future prospects

The burden of obesity on public health care and the national economy is expected to increase in the future, especially because of upward trends in the prevalence of hypertension and type 2 diabetes. The health hazards of obesity-related metabolic disorders overall will remain high or will become even more prominent since the prevalence of abdominal obesity seems to be on rise in Finnish adults.

Treatment of obesity is a great challenge for health care professionals, who must recognize obesity as a major determinant of several illnesses. Correspondingly, the treatment should be seen as a treatment for obesity-related comorbidity. However, as obesity develops over a long period and is difficult to treat, more effort should be invested in its prevention. Prevention should begin early in life, in childhood and adolescence. However, for adults, regular monitoring of BMI and fat distribution would be useful to control even modest weight gain with ageing, particularly at vulnerable ages and life stages with an increased risk of gaining weight. Such monitoring could easily become part of health examination activities offered in occupational health units and maternity health clinics.

Cross-sectional population surveys in which anthropometric measurements are taken should also be regularly carried out to monitor the distribution of BMI and the prevalence of obesity in the general population. In Finland, prospects for epidemiological research and monitoring of obesity are good. In the recent national health examination survey, Health 2000, measurements of body height, weight, waist and hip circumferences, abdominal sagittal diameter and bioimpedance were simultaneously carried out in a representative population sample. In addition, the next FINRISK study will be carried out in 2002. These surveys will give valuable information to predict future obesity-related problems and to evaluate the effectiveness of obesity prevention and treatment strategies.

Furthermore, health behaviour surveys including self-reported weights and heights could be used to monitor secular trends in obesity, so long as the underestimation which occurs with self-reporting is kept in mind. Data collected in large health surveys could also be utilized more efficiently in obesity research.

Since obesity has been shown to be related not only to a multitude of illnesses but also to disability and diminished quality of life, querying about weight and height should be a matter of course in all health-related questionnaires. In health examination surveys, supplementing anthropometric measurements with more sophisticated methods to investigate body composition of subjects would be useful. Prospective studies designed to investigate dietary factors, physical activity patterns and other lifestyle factors related to weight change are also needed to improve understanding of how obesity develops and how it can be prevented.

7. Conclusions

Based on the main findings, the following conclusions were drawn:

1. Mean BMI and prevalence of obesity have increased both in men and women over the last few decades, the most prominent increase taking place among older men and young adults. Especially in women, education is a strong determinant of normal weight. This social gradient has increased until the beginning of the 1990s such that women with the lowest education are the heaviest. In men, BMI increased in all educational groups. Also noteworthy is that BMI trends varied by occupation such that the most undesirable trends occurred in retired and unemployed men.

2. In the working-aged male population, older birth cohorts seem to have been replaced by younger, heavier birth cohorts. In men, the younger the birth cohort, the more prominent the BMI increase with age, whereas in women, this increase has remained unchanged over a 25-year period. However, a BMI increase with age is still more prominent in women than in men.

3. Independently of changes in BMI, abdominal obesity has increased over a ten-year period, with the most undesirable trend taking place among older subjects. In men, the strongest upward trend in waist-to-hip ratio (WHR) occurred at the end of the 1980s to the early 1990s, whereas in women, WHR increased steadily over the ten-year period. The adverse changes in body shape among older women are important to note when evaluating the finding of a plateau in obesity changes based on BMI.

4. Physical activity, no smoking, moderate alcohol consumption and healthy food choices were associated with the least likelihood of being obese. These lifestyle factors, excluding food choices, were also associated with WHR, although only a

minor part of the variation in WHR was explained by these factors. Most associations between BMI and lifestyle factors remained unchanged over time, but avoiding sedentariness became more important as a factor associated with normal weight.

In conclusion, obesity is an increasing problem in Finland, especially among young adults and older men. Men outside the work force and women with low education appear to have the most undesirable trends in obesity. This study also suggests that the role of physical activity in weight management has strengthened over the years, although the associations with other lifestyle factors remain important as well. These findings should be considered in planning public health action to prevent obesity.

8. Acknowledgements

The impetus for this thesis was provided by Professor Jussi Huttunen, General Director of the National Public Health Institute (KTL), who convinced me that science could be even more fun than running marathons. I am truly grateful for his unfailing encouragement and enthusiasm, not to mention provision of working facilities. Professor Antti Aro, head of the former Department of Nutrition, is also warmly acknowledged for support and inspiring discussions during this process.

I was lucky to have had a skilful, well-balanced trio of supervisors. Professor Pirjo Pietinen, however, deserves special mention. She is a wonderful person whose wide knowledge in the field of nutrition epidemiology is admirable, as is her openness. Her invaluable support throughout my career as a researcher will always be gratefully remembered.

Professor Erkki Vartiainen, who as my supervisor patiently taught me how to do good research, is also warmly acknowledged. Without his kind guidance, my interpretations would have been more doubtful. I am also grateful to my third supervisor, Docent Markku Heliövaara, who generously offered his opinions and ideas on how to improve this work. His astute observations, probing questions and prompt responses helped me greatly in times of anxiety.

I thank Professor Timo Hakulinen, Director of the Doctoral Program of Public Health, for providing excellent post graduate courses, for giving good advice during the final steps of this thesis and for friendly small talk - about skiing.

I am greatly indebted to Professors Seppo Sarna and Jacob Seidell for promptly reviewing the manuscript of my thesis and for their supportive comments. I am also grateful to Carol Ann Pelli, HonBSc, for carefully reviewing the English language of three of the original papers and this thesis.

This study was financially supported by the Juho Vainio Foundation and the Finnish Cultural Foundation. In addition, travel grants for scientific meetings were provided by the Finnish Association for the Study of Obesity, the Finnish

Society for Nutrition Research and the Association of Clinical and Public Health Nutritionists in Finland. All assistence is gratefully acknowledged.

The paintaking preparation of this thesis would have been quite boring without my outstanding colleagues at KTL. The co-authorship of Professor Pekka Jousilahti and Satu Männistö, PhD, is especially acknowledged. In addition, to sharing a workroom, Satu has shared the concerns of a young scientist and several pleasant congress trips with me. During the last year, Satu was “replaced” by Annamari Kilkkinen, MSc, who inherited not only Satu’s desk behind the wall but also her role as a good listener. Special thanks are also due to Heli Tapanainen, BSc, for helping with statistical questions, Heikki Pakkala, MSc, and Tommi Korhonen, MSc, for taking good care of *Lehtokurppa* and *Pikkusirkku* and Docent Liisa Valsta, for fruitful and relaxing discussions and opportunities to sing beautiful songs, the words of which I will never remember by heart.

Demanding work needs a good stress outlet. I am indebted to my skilful ex-coaches, Raimo, Kari and Timo, who strengthened my endless love for running, the vital source of my energy. I would also like to thank all my friends on and outside the tracks for warm companionship. I am particularly grateful to Tiina and Sari for sharing the ups and downs of the human condition.

I owe my heartfelt thanks to my dear parents, who have always let me, their only child try my own wings. *Äiti ja isä, kiitän sydämestäni rakkaudestanne, huolenpidostanne ja – ylipäätään kaikesta, mitä sanat eivät riitä kuvaamaan.*

And last but not least, my warmest thanks to my beloved husband Jouni and our wonderful sons Roope and Juuso for their love and patience. I feel blessed to have my three boys close to me. They make life worth living.

Järvenpää, September 2001

Marjaana Lahti-Koski

9. References

Ainsworth BE, Haskell WL, Leon AS, Jacobs DRJ, Montoye HJ, Sallis JF, Paffenbarger RSJ. Compendium of physical activities: classification of energy costs of human physical activities. Med Sci Sports Exerc 1993;25:71-80.

Albanes D, Jones DY, Micozzi MS, Mattson ME. Association between smoking and body weight in the US population: Analysis of NHANES II. Am J Public Health 1987;77:439-44.

Allison DB, Paultre F, Poehlman ET, Heymsfield SB. Statistical considerations regarding the use of ratios to adjust data. Int J Obes Relat Metab Disord 1995;19:644-52.

Appleby PN, Thorogood M, Mann JI, Key TJ. Low body mass index in non-meat eaters: the possible roles of animal fat, dietary fibre and alcohol. Int J Obes Relat Metab Disord 1998;22:454-60.

Aranceta J, Perez-Rodrigo C, Serra-Majem L, Ribas L, Quiles-Izquierdo J, Vioque J, Foz M. Influence of sociodemographic factors in the prevalence of obesity in Spain. The SEEDO'97 Study. Eur J Clin Nutr 2001;55:430-5.

Ashwell M, Cole TJ, Dixon AK. Obesity: new insight into the anthropometric classification of fat distribution shown by computed tomography. BMJ 1985;290:1692-4.

Barefoot JC, Heitmann BL, Helms MJ, Williams RB, Surwit RS, Siegler IC. Symptoms of depression and changes in body weight from adolescence to mid-life. Int J Obes Relat Metab Disord 1998;22:688-94.

Barrett-Connor E, Khaw K-T. Cigarette smoking and increased central adiposity. Ann Intern Med 1989;111:783-7.

Beer-Borst S, Morabia A, Hercberg S, Vitek O, Bernstein MS, Galan P, Galasso P, Giampaoli S, Houterman S, McCrum E, Panico S, Pannozzo F, Preziosi P, Ribas L, Serra-Majem L, Verschuren WMM, Yarnell J, Northridge ME. Obesity and other health determinants across Europe: The EURALIM Project. J Epidemiol Community Health 2000;54:424-30.

Bell EA, Castellanos VH, Pelkman CL, Thorwart ML, Rolls BJ. Energy density of foods affects energy intake in normal-weight women. Am J Clin Nutr 1998;67:412-20.

Bennett S. Cardiovascular risk factors in Australia: trends in socioeconomic inequalities. J Epidemiol Community Health 1995;49:363-72.

Bild DE, Sholinsky P, Smith DE, Lewis CE, Hardin JM, Burke GL. Correlates and predictors of weight loss in young adults: the CARDIA study. Int J Obes Relat Metab Disord 1996;20:47-55.

Björkelund C, Lissner L, Andersson S, Lapidus L, Bengtsson C. Reproductive history in relation to relative weight and fat distribution. Int J Obes Relat Metab Disord 1996;20:213-9.

Björntorp P. Regional patterns of fat distribution. Ann Intern Med 1985;103:994-5.

Björntorp P. Visceral obesity: a "civilization syndrome". Obes Res 1993;1:206-22.

Björntorp P. Etiology of the metabolic syndrome. In: Bray GA, Bouchard C, James WPT, eds. Handbook of obesity. 1st ed. New York: Marcel Dekker, Inc, 1998:573-600.

Blokstra A, Burns CM, Seidell JC. Perception of weight status and dieting behaviour in Dutch men and women. Int J Obes Relat Metab Disord 1999;23:7-17.

Blundell JE, Macdiarmid JI. Fat as a risk factor for overconsumption: satiation, satiety, and patterns of eating. J Am Diet Assoc 1997;97:S63-9.

Bouchard C. Can obesity be prevented? Nutr Rev 1996;54:S125-30.

Bouchard C, Bray GA, Hubbard VS. Basic and clinical aspects of regional fat distribution. Am J Clin Nutr 1990;52:946-50.

Boyle CA, Dobson AJ, Egger G, Magnus P. Can the increasing weight of Australians be explained by the decreasing prevalence of cigarette smoking? Int J Obes Relat Metab Disord 1994;18:55-60.

Bray GA. Overweight is risking fate. Definition, classification, prevalence and risks. Ann N Y Acad Sci 1987;499:14-28.

Bray GA, Popkin BM. Dietary fat intake does affect obesity! Am J Clin Nutr 1998;68:1157-73.

Brown JE, Kaye SA, Folsom AR. Parity-related weight change in women. Int J Obes Relat Metab Disord 1992;16:627-31.

Brunner EJ, Wunsch H, Marmot MG. What is an optimal diet? Relationship of macronutrient intake to obesity, glucose tolerance, lipoprotein cholesterol levels and the metabolic syndrome in the Whitehall II study. Int J Obes Relat Metab Disord 2001;25:45-53.

Burke GL, Savage PJ, Manolio TA, Sprafka JM, Wagenknecht LE, Sidney S, Perkins LL, Liu K, Jacobs JR DR. Correlates of obesity in young black and white women: The CARDIA Study. Am J Public Health 1992;82:1621-5.

Caetano R. Cultural and subgroup issues in measuring consumption. Alcohol Clin Exp Res 1998;22:21S-8S.

Cairney J, Wade TJ. Correlates of body weight in the 1994 National Population Health Survey. Int J Obes Relat Metab Disord 1998;22:584-91.

Carey VJ, Walters EE, Colditz GA, Solomon CG, Willett WC, Rosner BA, Speizer FE, Manson JE. Body fat distribution and risk of non-insulin-dependent diabetes mellitus in women. Am J Epidemiol 1997;145:614-9.

Chen Y, Horne SL, Dosman JA. The influence of smoking cessation on body weight may be temporary. Am J Public Health 1993;83:1330-2.

Coakley EH, Rimm EB, Colditz G, Kawachi I, Willett W. Predictors of weight change in men: Results from The Health Professionals Follow-Up Study. Int J Obes Relat Metab Disord 1998;22:89-96.

Colditz GA. Economic costs of obesity? Am J Clin Nutr 1992;55:S503-7.

Colditz GA, Willett WC, Stampfer MJ, London SJ, Segal MR, Speizer FE. Patterns of weight change and their relation to diet in a cohort of healthy women. Am J Clin Nutr 1990;51:1100-5.

Colditz GA, Giovannucci E, Rimm EB, Stampfer MJ, Rosner B, Speizer FE, Gordis E, Willett WC. Alcohol intake in relation to diet and obesity in women and men. Am J Clin Nutr 1991;54:49-55.

Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000;320:1240-3.

Colliver JA, Frank S, Frank A. Similarity of obesity indices in clinical studies of obese adults: a factor analytic study. Am J Clin Nutr 1983;38:640-7.

Cooper AR, Page A, Fox KR, Misson J. Physical activity patterns in normal, overweight and obese individuals using minute-by-minute accelerometry. Eur J Clin Nutr 2000;54:887-94.

Cooper R, Durazo-Arvizu R, Luke A, McGee D. A contrary view on the search for weight guidelines. Nutr Metab Cardiovasc Dis 1998;8:117-20.

Cox DN, Mela DJ. Determination of energy density of freely selected diets: methodological issues and implications. Int J Obes Relat Metab Disord 2000;24:49-54.

Cox DN, Perry L, Moore PB, Vallis L, Mela DJ. Sensory and hedonic associations with macronutrient and energy intakes of lean and obese consumers. Int J Obes Relat Metab Disord 1999;23:403-10.

Crawford DA, Jeffrey RW, French SA. Television viewing, physical inactivity and obesity. Int J Obes Relat Metab Disord 1999;23:437-40.

Crocker J, Cornwell B, Major B. The stigma of overweight: Affective consequences of attributional ambiguity. J Pers Soc Psychol 1993;64:60-70.

Delvaux K, Lysens R, Philippaerts R, Thomis M, Vanreusel B, Claessens AL, Vanden Eynde B, Beunen G, Lefevre J. Associations between physical activity, nutritional practices and health-related anthropometry in Flemish males: a 5-year follow-up study. Int J Obes Relat Metab Disord 1999;23:1233-41.

Després J-P, Prud´homme D, Pouliot M-C, Tremblay A, Bouchard C. Estimation of deep abdominal adipose-tissue accumulation from simple anthropometric measurements in men. Am J Clin Nutr 1991;54:471-7.

Deurenberg P, Yap M, van Staveren WA. Body mass index and percent body fat: a meta-analysis among different ethnic groups. Int J Obes Relat Metab Disord 1998;22:1164-71.

de Vries JHM, Lemmens PHHM, Pietinen P, Kok FJ. Assessment of alcohol consumption. In: Macdonald I, ed. Health issues related to alcohol consumption. 2nd ed. London: Blackwell Science Ltd, 1999:27-62.

DiPietro L. Physical activity in the prevention of obesity: current evidence and research issues. Med Sci Sports Exerc 1999;31:S542-6.

Doll HA, Petersen SEK, Stewart-Brown SL. Obesity and physical and emotional well-being: Associations between body mass index, chronic illness, and the physical and mental components of the SF-36 questionnaire. Obes Res 2000;8:160-70.

Doucet E, Alméras N, White MD, Després J-P, Bouchard C, Tremblay A. Dietary fat composition and human adiposity. Eur J Clin Nutr 1998;52:2-6.

Eckersley RM. Losing the battle of the bulge: causes and consequences of increasing obesity. Med J Aust 2001;174:590-2.

Egger G, Swinburn B. An "ecological" approach to the obesity pandemic. BMJ 1997;315:477-80.

Fentem PH, Mockett SJ. Physical activity and body composition: What do the national surveys reveal? Int J Obes Relat Metab Disord 1998;22, suppl 2:S8-S14.

Filozof C, Gonzalez C. Predictors of weight gain: the biological-behavioural debate. Obesity Reviews 2000;1:21-6.

Flegal KM, Carroll MD, Kuczmarski RJ, Johnson CL. Overweight and obesity in the United States: prevalence and trends, 1960-1994. Int J Obes Relat Metab Disord 1998;22:39-47.

Fogelholm M, Kukkonen-Harjula K. Does physical activity prevent weight gain - a systematic review. Obesity Reviews 2000;1:95-112.

Fogelholm M, Männistö S, Vartiainen E, Pietinen P. Determinants of energy balance and overweight in Finland 1982 and 1992. Int J Obes Relat Metab Disord 1996;20:1097-104.

Folsom AR, Stevens J, Schreiner PJ, McGovern PG. Body mas index, waist/hip ratio, and coronary heart disease incidence in African Americans and whites. Am J Epidemiol 1998;148:1187-94.

Forbes GB. Longitudinal changes in adult fat-free mass: influence of body weight. Am J Clin Nutr 1999;70:1025-31.

Ford ES, Moriarty DG, Zack MM, Mokdad AH, Chapman DP. Self-reported body mass index and health-related quality of life: Findings from the Behavioral Risk Factor Surveillance System. Obes Res 2001;9:21-31.

French SA, Jeffery RW, Forster JL, McGovern PG, Kelder SH, Baxter JE. Predictors of weight change over two years among a population of working adults: the Healthy Worker Project. Int J Obes Relat Metab Disord 1994;18:145-54.

Gallagher D, Visser M, Sepúlveda D, Pierson RN, Harris T, Heymsfield SB. How useful is body mass index for comparison of body fatness across age, sex, and ethnic groups? Am J Epidemiol 1996;143:228-39.

Garn SM. Fractionating healthy weight. Am J Clin Nutr 1996;63:S412-4.

Garn SM, Leonard WR, Hawthorne VM. Three limitations of the body mass index. Am J Clin Nutr 1986;44:996-7.

Gill TP. Key issues in the prevention of obesity. Br Med Bull 1997;53:359-88.

Glenny A-M, O'Meara S, Melville A, Sheldon TA, Wilson C. The treatment and prevention of obesity: a systematic review of the literature. Int J Obes Relat Metab Disord 1997;21:715-37.

Gortmaker SL, Must A, Perrin JM, Sobol AM, Dietz WH. Social and economic consequences of overweight in adolescence and young adulthood. N Engl J Med 1993;329:1008-12.

Gray DS, Fujioka K. Use of relative weight and body mass index for the determination of adiposity. J Clin Epidemiol 1991;44:545-50.

Gray DS, Fujioka K, Colletti PM, Kim H, Devine W, Cuyegkeng T, Pappas T. Magnetic-resonance imaging used for determining fat distribution in obesity and diabetes. Am J Clin Nutr 1991;54:623-7.

Guo SS, Zeller C, Chumlea WC, Siervogel RM. Aging, body composition, and lifestyle: the Fels Longitudinal Study. Am J Clin Nutr 1999;70:405-11.

Gutiérrez-Fisac JL, Regidor E, Rodríguez C. Trends in obesity differences by educational level in Spain. J Clin Epidemiol 1996;49:351-4.

Gutierréz-Fisac JL, Banegas Banegas JR, Rodríguez Artalejo F, Regidor E. Increasing prevalence of overweight and obesity among Spanish adults, 1987-1997. Int J Obes Relat Metab Disord 2000;24:1677-82.

Haapanen N, Miilunpalo S, Pasanen M, Oja P, Vuori I. Association between leisure time physical activity and 10-year body mass change among working-aged men and women. Int J Obes Relat Metab Disord 1997;21:288-96.

Han TS, McNeill G, Seidell JC, Lean MEJ. Predicting intra-abdominal fatness from anthropometric measures: the influence of stature. Int J Obes Relat Metab Disord 1997a;21:587-93.

Han TS, Seidell JC, Curall JEP, Morrison CE, Deurenberg P, Lean MEJ. The influeces of height and age on waist circumference as an index of adiposity in adults. Int J Obes Relat Metab Disord 1997b;21:83-9.

Hardeman W, Griffin S, Johnston M, Kinmonth AL, Wareham NJ. Interventions to prevent weight gain: a systematic review of psychological models and behaviour change methods. Int J Obes Relat Metab Disord 2000;24:131-43.

Hartz AJ, Rupley DC jr, Kalkhoff RD, Rimm AA. Relationship of obesity to diabetes: influence of obesity level and body fat distribution. Prev Med 1983;12:351-7.

Hebert JR, Clemow L, Pbert L, Ockene IS, Ockene JK. Social desirability bias in dietary self-report may compromise the validity of dietary intake measures. Int J Epidemiol 1995;24:389-98.

Heerstrass DW, Ocké MC, Bueno-de-Mesquita HB, Peeters PHM, Seidell JC. Underreporting of energy, protein and potassium intake in relation to body mass index. Int J Epidemiol 1998;27:186-93.

Heinemann LAJ, Garbe E, Classen E, Willich SN, Barth W, Thiel C. Trends im kardiovaskulären Risikofaktorenprofil in Ostdeutschland - Drei unabhängige Bevölkerungsuntersuchungen im Rahmen des Projekts MONICA Ostdeutschland. Dtsch Med Wochenschr 1998;123:889-95.

Heitmann BL. The influence of fatness, weight change, slimming history and other lifestyle variables on diet reporting in Danish men and women aged 35-65 years. Int J Obes Relat Metab Disord 1993;17:329-36.

Heitmann BL. Ten-year trends in overweight and obesity among Danish men and women aged 30-60 years. Int J Obes Relat Metab Disord 2000;24:1347-52.

Heitmann BL, Garby L. Patterns of long-term weight changes in overweight developing Danish men and women aged between 30 and 60 years. Int J Obes Relat Metab Disord 1999;23:1074-8.

Heitmann BL, Lissner L. Dietary underreporting by obese individuals -is it specific or non-specific? BMJ 1995;311:986-9.

Heitmann BL, Lissner L, Sorensen TIA, Bengtsson C. Dietary fat intake and weight gain in women genetically predisposed for obesity. Am J Clin Nutr 1995;61:1213-7.

Heitmann BL, Lissner L, Osler M. Do we eat less fat, or just report so? Int J Obes Relat Metab Disord 2000;24:435-42.

Helakorpi S, Uutela A, Prättälä R, Puska P. Health Behaviour and health among Finnish adult population, spring 2000. Publications of the National Public Health Institute B8/2000, Helsinki, 2000.

Heliövaara M, Aromaa A. Parity and obesity. J Epidemiol Community Health 1981;35:197-9.

Hellerstedt WL, Jeffery RW, Murray DM. The association between alcohol intake and adiposity in the general population. Am J Epidemiol 1990;132:594-611.

Helmert U, Shea S, Maschewsky-Schneider U. Social class and cardiovascular disease risk factor changes in West Germany 1984-1991. Eur J Public Health 1995;5:103-8.

Higgins M, Kannel W, Garrison R, Pinsky J, Stokes J. Hazards of obesity - the Framingham experience. Acta Med Scand 1988;723:23-36.

Hill AJ, Bhatti R. Body shape perception and dieting in preadolescent British Asian girls: links with eating disorders. Int J Eat Disord 1995;17:175-83.

Hill JO, Peters JC. Environmental contributions to the obesity epidemic. Science 1998;280:1371-4.

Hill JO, Melanson EL, Wyatt HT. Dietary fat intake and regulation of energy balance: implications for obesity. J Nutr 2000;130:284S-8S.

Hjartåker A, Lund E. Relationship between dietary habits, age, lifestyle, and socio-economic status among adult Norwegian women. The Norwegian Women and Cancer Study. Eur J Clin Nutr 1998;52:565-72.

Hoffmeister H, Mensink GBM, Stolzenberg H. National trends in risk factors for cardiovascular disease in Germany. Prev Med 1994;23:197-205.

Istvan JA, Cunningham TW, Garfinkel L. Cigarette smoking and body weight in the Cancer Prevention Study I. Int J Epidemiol 1992;21:849-53.

James WPT. A public health approach to the problem of obesity. Int J Obes Relat Metab Disord 1995;19:S37-45.

Janssen I, Heymsfield SB, Wang Z, Ross R. Skeletal muscle mass and distribution in 468 men and women aged 18-88 yr. J Appl Physiol 2000;89:81-8.

Jebb SA, Elia M. Techniques for the measurement of body composition: a practical guide. Int J Obes Relat Metab Disord 1993;17:611-21.

Jeffery RW, French SA. Epidemic obesity in the United States: Are fast foods and television viewing contributing? Am J Public Health 1998;88:277-80.

Jéquier E. Alcohol intake and body weight: a paradox. Am J Clin Nutr 1999;69:173-4.

Johansson L, Solvoll K, Bjorneboe G-EA, Drevon CA. Under- and overreporting of energy intake related to weight status and lifestyle in a nationwide sample. Am J Clin Nutr 1998;68:266-74.

Jorgensen LM, Sorensen TIA, Schroll M, Larsen S. Influence of dietary factors on weight change assessed by multivariate graphical models. Int J Obes Relat Metab Disord 1995;19:909-15.

Kaaks R, van Noord PAH, den Tonkelaar I, Peeters PHM, Riboli E, Grobbee DE. Breast-cancer incidence in relation to height, weight and body-fat distribution in the Dutch "DOM" cohort. Int J Cancer 1998;76:647-51.

Kahn HS. Choosing an index for abdominal obesity: an opportunity for epidemiologic clarification. J Clin Epidemiol 1993;46:491-4.

Kahn HS, Williamson DF. The contributions of income, education and changing marital status to weight change among US men. Int J Obes Relat Metab Disord 1990;14:1057-68.

Kahn HS, Williamson DF, Stevens JA. Race and weight change in US Women: The roles of socioeconomic and marital status. Am J Public Health 1991;81:319-23.

Kannel WB, Cupples LA, Ramaswami R, Stokes III J, Kreger BE, Higgins M. Regional obesity and risk of cardiovascular disease: The Framingham Study. J Clin Epidemiol 1991;44:183-90.

Kant AK, Graubard BI, Schatzkin A, Ballard-Barbash R. Proportion of energy intake from fat and subsequent weight change in the NHANES I Epidemiologic Follow-up Study. Am J Clin Nutr 1995;61:11-7.

Keys A, Fidanza F, Karvonen MJ, Kimura N, Taylor HL. Indices of relative weight and obesity. J Chronic Dis 1971;25:329-43.

Klesges RC, Klesges LM, Haddock CK, Eck LH. A longitudinal analysis of the impact of dietary intake and physical activity on weight change in adults. Am J Clin Nutr 1992;55:818-22.

Kromhout D, Saris WHM, Horst CH. Energy intake, energy expenditure, and smoking in relation to body fatness: the Zutphen Study. Am J Clin Nutr 1988;47:668-74.

Krotkiewski M, Björntorp P, Sjöström L, Smith U. Impact of obesity on metabolism in men and women. Importance of regional adipose tissue distribution. J Clin Invest 1983;72:1150-62.

Kuczmarski MF, Kuczmarski RJ, Najjar M. Effects of age on validity of self-reported height, weight, and body mass index: Findings from the third National Health and Nutrition Examination Survey, 1988-1994. J Am Diet Assoc 2001;101:28-34.

Kuczmarski RJ, Flegal KM, Campbell SM, Johnson CL. Increasing prevalence of overweight among US adults. The National Health and Nutrition Examination Surveys, 1960 to 1991. JAMA 1994;272:205-11.

Laaksonen M, Rahkonen O, Prättälä R. Smoking status and relative weight by educational level in Finland, 1978-1995. Prev Med 1998;27:431-7.

Lafay L, Basdevant A, Charles M-A, Vray M, Balkau B, Borys J-M, Eschwège E, Romon M. Determinants and nature of dietary underreporting in a free-living population: the Fleurbaix Laventie Ville Santé (FLVS) study. Int J Obes Relat Metab Disord 1997;21:567-73.

Lahman PH, Lissner L, Gullberg B, Berglund G. Differences in body fat and central adiposity between Swedes and European immigrants: the Malmö Diet and Cancer Study. Obes Res 2000a;8:620-31.

Lahman PH, Lissner L, Gullberg B, Berglund G. Sociodemographic factors associated with long-term weight gain, current body fatness and central adiposity in Swedish women. Int J Obes Relat Metab Disord 2000b;24:685-94.

Lallukka T, Lahti-Koski M, Ovaskainen M-L. Vegetable and fruit consumption and its determinants in young Finnish adults. Scand J Nutr 2001;in press.

Lapidus L, Bengtsson C, Larsson B, Pennert K, Rybo E, Sjöström L. Distribution of adipose tissue and risk of cardiovascular disease and death: a 12 year follow up of participants in the population study of women in Gothenburg, Sweden. BMJ 1984;289:1257-61.

Larsson B, Svärdsudd K, Welin L, Wilhelmsen L, Björntorp P, Tibblin G. Abdominal adipose tissue distribution, obesity and risk of cardiovascular disease and death: 13 year follow-up of participants in the study of men born in 1913. BMJ 1984;288:1401-4.

Laurier D, Guiguet M, Chau NP, Wells JA, Valleron A-J. Prevalence of obesity: a comparative survey in France, the United Kingdom and the United States. Int J Obes Relat Metab Disord 1992;16:565-72.

Lean MEJ, Han TS, Morrison CE. Waist circumference as a measure for indicating need for weight management. BMJ 1995;311:158-61.

Lean MEJ, Han TS, Seidell JC. Impairment of health and quality of life in people with large waist circumference. Lancet 1998;351:853-6.

Lemieux S, Prud'homme D, Bouchard C, Tremblay A, Després J-P. A single threshold value of waist girth identifies normal-weight and overweight subjects with excess visceral adipose tissue. Am J Clin Nutr 1996;64:685-93.

Lewis CE, Smith DE, Wallace DD, Williams OD, Bild DE, Jacobs DR. Seven-year trends in body weight and associations with lifestyle and behavioral characteristics in black and white young adults: the CARDIA Study. Am J Public Health 1997;87:635-42.

Lissner L. Psychosocial aspects of obesity: Individual and societal perspectives. Scand J Nutr 1997;41:75-9.

Lissner L, Heitmann BL. Dietary fat and obesity: evidence from epidemiology. Eur J Clin Nutr 1995;49:79-90.

Lissner L, Björkelund C, Heitmann BL, Lapidus L, Björntorp P, Bengtsson C. Secular increases in waist-hip ratio among Swedish women. Int J Obes Relat Metab Disord 1998;22:1116-20.

Lissner L, Johansson S-E, Qvist J, Rössner S, Wolk A. Social mapping of the obesity epidemic in Sweden. Int J Obes Relat Metab Disord 2000;24:801-5.

Liu S, Manson JE. What is the optimal weight for cardiovascular health? BMJ 2001;322:631-2.

Ludwig DS. Dietary glycemic index and obesity. J Nutr 2000;130:280S-3S.

Lukaski HC. Methods for the assessment of human body composition: traditional and new. Am J Clin Nutr 1987;46:537-56.

Macdiarmid JI, Cade JE, Blundell JE. High and low fat consumers, their macronutrient intake and body mass index: further analysis of the National Diet and Nutrition Survey of British Adults. Eur J Clin Nutr 1996;50:505-12.

Macdonald I, Debry G, Westerterp K. Alcohol and overweight. In: Verschuren PM, ed. Health issues related to alcohol consumption. 1st ed. Brussels: ILSI,Europe, 1993:263-79.

Macdonald SM, Reeder BA, Chen Y, Després J-P. Obesity in Canada: a descriptive analysis. Can Med Assoc J 1997;157:S3-9.

Männistö S, Pietinen P, Haukka J, Ovaskainen M-L, Albanes D, Virtamo J. Reported alcohol intake, diet and body mass index in male smokers. Eur J Clin Nutr 1996a;50:239-45.

Männistö S, Pietinen P, Pyy M, Palmgren J, Eskelinen M, Uusitupa M. Body-size indicators and risk of breast cancer according to menopause and estrogen-receptor status. Int J Cancer 1996b;68:8-13.

Männistö S, Uusitalo K, Roos E, Fogelholm M, Pietinen P. Alcohol beverage drinking, diet and body mass index in a cross-sectional survey. Eur J Clin Nutr 1997;51:326-32.

Manderbacka K, Lahelma E, Martikainen P. Examining the continuity of self-rated health. Int J Epidemiol 1998;27:208-13.

Manson JE, Willett WC, Stampfer MJ, Colditz GA, Hunter DJ, Hankinson SE, Hennekens CH, Speizer FE. Body weight and mortality among women. N Engl J Med 1995;333:677-85.

Marti B, Tuomilehto J, Korhonen HJ, Kartovaara L, Vartiainen E, Pietinen P, Puska P. Smoking and leanness: evidence for change in Finland. BMJ 1989;298:1287-90.

Marti-Henneberg C, Capdevila F, Arija V, Perez S, Cuco G, Vizmanos B, Fernandez-Ballart J. Energy density of the diet, food volume and energy intake by age and sex in healthy population. Eur J Clin Nutr 1999;53:421-8.

Martínez JA, Kearney JM, Kafatos A, Paquet S, Martínez-González MA. Variables independently associated with self-reported obesity in the European Union. Public Health Nutr 1999;2:125-33.

Martínez-González MA, Martínez JA, Hu FB, Gibney MJ, Kearney J. Physical activity, sedentary lifestyle and obesity in the European Union. Int J Obes Relat Metab Disord 1999;23:1192-201.

McCrory MA, Fuss PJ, McCallum JE, Yao M, Vinken AG, Hays NP, Roberts SB. Dietary variety within food groups: association with energy intake and body fatness in men and women. Am J Clin Nutr 1999;69:440-7.

McCrory MA, Fuss PJ, Saltzman E, Roberts SB. Dietary determinants of energy intake and weight regulation in healthy adults. J Nutr 2000;130:276S-9S.

Megnien JL, Denarie N, Cocaul M, Simon A, Levenson J. Predictive value of waist-to-hip ratio on cardiovascular risk events. Int J Obes Relat Metab Disord 1999;23:90-7.

Miller KJ, Gleaves DH, Hirsch TG, Green BA, Snow AC, Corbett CC. Comparisons of body image dimensions by race/ethnicity and gender in a university population. Int J Eat Disord 2000;27:310-6.

Miller WC, Lindeman AK, Wallace J, Niederpruem M. Diet composition, energy intake, and exercise in relation to body fat in men and women. Am J Clin Nutr 1990;52:426-30.

Mizoue T, Ueda R, Tokui N, Hino Y, Yoshimura T. Body mass decrease after initial gain following smoking cessation. Int J Epidemiol 1998;27:984-8.

Moens G, van Gaal L, Muls E, Viaene B, Jacques P. Body mass index and health among the working population. Epidemiologic data from Belgium. Eur J Public Health 1999;9:119-23.

Molarius A, Seidell JC. Differences in the association between smoking and relative body weight by level of education. Int J Obes Relat Metab Disord 1997;21:189-96.

Molarius A, Seidell JC. Selection of anthropometric indicators for classification of abdominal fatness -a critical review. Int J Obes Relat Metab Disord 1998;22:719-27.

Molarius A, Seidell JC, Kuulasmaa K, Dobson AJ, Sans S. Smoking and relative body weight: an international perspective from the WHO MONICA project. J Epidemiol Community Health 1997;51:252-60.

Molarius A, Seidell JC, Sans S, Tuomilehto J, Kuulasmaa K. Varying sensitivity of waist action levels to identify subjects with overweight or obesity in 19 populations of the WHO MONICA Project. J Clin Epidemiol 1999a;52:1213-24.

Molarius A, Seidell JC, Sans S, Tuomilehto J, Kuulasmaa K. Waist and hip circumferences, and waist-hip ratio in 19 populations of the WHO MONICA Project. Int J Obes Relat Metab Disord 1999b;23:116-25.

Molarius A, Seidell JC, Sans S, Tuomilehto J, Kuulasmaa K. Educational level, relative body weight, and changes in their association over 10 years: an international perspective from the WHO MONICA Project. Am J Public Health 2000;90:1260-8.

Morabia A, Bernstein M, Héritier S, Ylli A. Community-based surveillance of cardiovascular risk factors in Geneva: methods, resulting distribution, and comparisons with other populations. Prev Med 1997;26:311-9.

Morris JK, Cook DG, Shaper AG. Non-employment and changes in smoking, drinking, and body weight. BMJ 1992;304:536-41.

Myers A, Rosen JC. Obesity stigmatization and coping: relation to mental health symptoms, body image, and self-esteem. Int J Obes Relat Metab Disord 1999;23:221-30.

Niemi I, Pääkkönen H. Time use change in Finland in the 1980s. Helsinki: Central Statistical Office for Finland, 1990.

Öhlin A, Rössner S. Trends in eating patterns, physical activity and sociodemographic factors in relation to postpartum body weight development. Br J Nutr 1994;71:457-70.

Ogden J, Chanana A. Explaining the effect of ethnic group on weight concern: finding a role for family values. Int J Obes Relat Metab Disord 1998;22:641-7.

O'Hara P, Connett JE, Lee WW, Nides M, Murray R, Wise R. Early and late weight gain following smoking cessation in the Lung Health Study. Am J Epidemiol 1998;148:821-30.

Owens JF, Matthews KA, Wing RR, Kuller LH. Can physical activity mitigate the effects of aging in middle-aged women? Circulation 1992;85:1265-70.

Parker DR, Gonzalez S, Derby CA, Gans KM, Lasater TM, Carleton RA. Dietary factors in relation to weight change among men and women from two southeastern New England communities. Int J Obes Relat Metab Disord 1997;21:103-9.

Pekurinen M, Pokka-Vuento M, Salo H, Idänpää-Heikkilä U. Lihavuus ja terveysmenot Suomessa 1997. Suom Lääkäril 2000;55:11-6.

Peltonen M, Huhtasaari F, Stegmayer B, Lundberg V, Asplund K. Secular trends in social patterning of cardiovascular risk factor levels in Sweden. The Northern Sweden MONICA Study 1986-1994. J Intern Med 1998;244:1-9.

Pietinen P, Vartiainen E, Männistö S. Trends in body mass index and obesity among adults in Finland from 1972 to 1992. Int J Obes Relat Metab Disord 1996;20:114-20.

Pi-Sunyer FX. Health implications of obesity. Am J Clin Nutr 1991;53:S1595-603.

Popkin BM, Doak CM. The obesity epidemic is a worldwide phenomenon. Nutr Rev 1998;56:106-14.

Poppitt SD. Energy density of diets and obesity. Int J Obes Relat Metab Disord 1995;19:S20-6.

Poppitt SD, Prentice AM. Energy density and its role in the control of food intake: evidence from metabolic and community studies. Appetite 1996;26:153-74.

Pouliot M-C, Després J-P, Lemieux S, Moorjani S, Bouchard C, Tremblay A, Nadeau A, Lupien PJ. Waist circumference and abdominal sagittal diameter: Best simple anthropometric indexes of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. Am J Cardiol 1994;73:460-8.

Prentice AM. Alcohol and obesity. Int J Obes Relat Metab Disord 1995;19:S44-50.

Prentice AM. Body mass index standards for children. BMJ 1998;317:1401-2.

Prentice AM, Jebb SA. Obesity in Britain: gluttony or sloth? BMJ 1995;311:437-9.

Puska P, Helakorpi S, Prättälä R, Uutela A. Suomalaisten painokäyrä noususuunnassa-aikuisväestön terveyskäyttäytymisseurannan tuloksia. Suom Lääkäril 1996;30:3123-8.

Rahkonen O, Lundberg O, Lahelma E, Huuhka M. Body mass and social class: A comparison of Finland and Sweden in the 1990s. J Public Health Policy 1998;19:88-105.

Rankinen T, Kim S-Y, Pérusse L, Després J-P, Bouchard C. The prediction of abdominal visceral fat level from body composition and anthropometry: ROC analysis. Int J Obes Relat Metab Disord 1999;23:801-9.

Ravussin E, Tataranni A. Dietary fat and human obesity. J Am Diet Assoc 1997;97:S42-6.

Rehm J. Measuring quality, frequency, and volume of drinking. Alcohol Clin Exp Res 1998;22:4S-14S.

Reunanen A. Lihavuuden yleisyys. Duodecim 1990;106:465-71.

Revicki DA, Israel RG. Relationship between body mass indices and measures of body adiposity. Am J Public Health 1986;76:992-4.

Rexrode KM, Carey VJ, Hennekens CH, Walters EE, Colditz GA, Stampfer MJ, Willett WC, Manson JE. Abdominal adiposity and coronary heart disease in women. JAMA 1998;280:1843-8.

Rissanen A, Heliövaara M, Aromaa A. Overweight and anthropometric changes in adulthood: a prospective study of 17 000 Finns. Int J Obes Relat Metab Disord 1988;12:391-401.

Rissanen A, Heliövaara M, Knekt P, Reunanen A, Aromaa A, Maatela J. Risk of disability and mortality due to overweight in a Finnish population. BMJ 1990;301:835-7.

Rissanen AM, Heliövaara M, Knekt P, Reunanen A, Aromaa A. Determinants of weight gain and overweight in adult Finns. Eur J Clin Nutr 1991;45:419-30.

Roberts SB, Heyman MB. Dietary composition and obesity: Do we need to look beyond dietary fat? J Nutr 2000;130:267S.

Rössner S, Öhlin A. Pregnancy as a risk factor for obesity: lessons from the Stockholm Pregnancy and Weight Development Study. Obes Res 1995;3:267s-75s.

Rolland-Cachera MF, Cole TJ, Sempé M, Tichet J, Rossignol C, Charraud A. Body mass index variations: centiles from birth to 87 years. Eur J Clin Nutr 1991;45:13-21.

Rolls BJ. The role of energy density in the overconsumption of fat. J Nutr 2000;130:S268-71.

Rolls BJ, Miller DL. Is the low-fat message giving people a license to eat more? Journal of the American College of Nutrition 1997;16:535-43.

Rolls BJ, Bell EA, Castellanos VH, Chow M, Pelkman CL, Thorwart ML. Energy density but not fat content of foods affected energy intake in lean and obese women. Am J Clin Nutr 1999;69:863-71.

Rona RJ, Morris RW. National study of health and growth: social and family factors and overweight in English and Scottish parents. Ann Hum Biol 1982;9:147-56.

Roos E. Social patterning of food behaviour among Finnish men and women [Thesis]. Publications of the National Public Health Institute A6/1998, Helsinki, 1998.

Rosengren A, Eriksson H, Larsson B, Svärdudd K, Tibblin G, Welin L, Wilhelmsen L. Secular changes in cardiovascular risk factors over 30 year in Swedish men aged 50: the study of men born in 1913, 1923, 1933 and 1943. J Intern Med 2000;247:111-8.

Rosmond R, Lapidus L, Björntorp P. The influence of occupational and social factors on obesity and body fat distribution in middle-aged men. Int J Obes Relat Metab Disord 1996;20:599-607.

Ross R, Shaw KD, Rissanen J, Martel Y, Guise de J, Avruch L. Sex differences in lean and adipose tissue distribution by magnetic resonance imaging: anthropometric relationship. Am J Clin Nutr 1994;59:1277-85.

Rowland ML. Self-reported weight and height. Am J Clin Nutr 1990;52:1125-33.

Salmon J, Bauman A, Crawford D, Timperio A, Owen N. The association between television vieving and overweight among Australian adults participating in varying levels of leisure-time physical activity. Int J Obes Relat Metab Disord 2000;24:600-6.

Sarlio-Lähteenkorva S, Lahelma E. The association of body mass index with social and economic disadvantage in women and men. Int J Epidemiol 1999;28:445-9.

Seidell JC. The impact of obesity on health status: Some implications for health care costs. Int J Obes Relat Metab Disord 1995a;19:S13-6.

Seidell JC. Obesity in Europe. Obes Res 1995b;3:S89-93.

Seidell JC. Obesity in Europe: scaling an epidemic. Int J Obes Relat Metab Disord 1995c;19:S1-4.

Seidell JC. Time trends in obesity: an epidemiological perspective. Horm Metab Res 1997;29:155-8.

Seidell JC. Dietary fat and obesity: an epidemiologic perspective. Am J Clin Nutr 1998;67:S546-50.

Seidell JC. The epidemiology of obesity. In: Björntorp P, ed. International Textbook of Obesity. 1st ed. John Wiley & Sons, 2001:23-30.

Seidell JC, Bouchard C. Visceral fat in relation to health: is it a major culprit or simply an innocent bystander? Int J Obes Relat Metab Disord 1997;21:626-31.

Seidell JC, Flegal KM. Assessing obesity: classification and epidemiology. Br Med Bull 1997;53:238-52.

Seidell JC, Oosterlee A, Thijssen MA, Burema J, Deurenberg P, Hautvast JG, Ruijs JH. Assessment of intra-abdominal and subcutaneous abdominal fat: Relation between anthropometry and computed tomography. Am J Clin Nutr 1987;45:7-13.

Seidell JC, Oosterlee A, Deurenberg P, Hautvast JGAJ, Ruijs JHJ. Abdominal fat depots measured with computed tomography: effects of degree of obesity, sex and age. Eur J Clin Nutr 1988;42:805-15.

Seidell JC, Cigolini M, Deslypere J-P, Charzewska J, Ellisinger B-M, Cruz A. Body fat distribution in relation to physical activity and smoking habits in 38-year-old European men. Am J Epidemiol 1991;133:257-65.

Seidell JC, Verschuren WMM, Kromhout D. Prevalence and trends of obesity in The Netherlands 1987-1991. Int J Obes Relat Metab Disord 1995;19:924-7.

Seidell JC, Han TS, Feskens EJM, Lean MEJ. Narrow hips and broad waist circumferences independently contribute to increased risk of non-insulin-dependent diabetes mellitus. J Intern Med 1997;242:401-6.

Seidell JC, Kahn HS, Williamson DF, Lissner L, Valdez R. Report from a Centers for Disease Control and Prevention Workshop on use of adult anthropometry for public healh and primary health care. Am J Clin Nutr 2001;73:123-6.

Sherwood NE, Jeffery RW, French SA, Hannan PJ, Murray DM. Predictors of weight gain in the Pound of Prevention Study. Int J Obes Relat Metab Disord 2000;24:395-403.

Simmons G, Jackson R, Swinburn B, Yee RL. The increasing prevalence of obesity in New Zealand: is it related to recent trends in smoking and physical activity? NZ Med J 1996;109:90-2.

Slattery ML, McDonald A, Bild DE, Caan BJ, Hilner JE, Jacobs Jr DR, Liu K. Associations of body fat and its distribution with dietary intake, physical activity, alcohol, and smoking in blacks and whites. Am J Clin Nutr 1992;55:943-9.

Smith DE, Lewis CE, Caveny JL, Perkins LL, Burke GL, Bild DE. Longitudial changes in adiposity associated with pregnancy. JAMA 1994;271:1747-51.

Smith DE, Thompson JK, Raczynski JM, Hilner JE. Body image among men and women in a biracial cohort: The CARDIA study. Int J Eat Disord 1999;25:71-82.

Sobal J, Stunkard AJ. Socioeconomic status and obesity: A review of the literature. Psychol Bull 1989;105:260-75.

Sobal J, Rauschenbach BS, Frongillo EA. Marital status, fatness and obesity. Soc Sci Med 1992;35:915-23.

Sobol W, Rossner S, Hinson B, Hiltbrandt E, Karstaedt N, Santago P, Wolfman N. Evaluation of a new magnetic resonance imaging method for quantitating adipose tissue areas. Int J Obes Relat Metab Disord 1991;15:589-99.

Sorkin JD, Muller DC, Andres R. Longitudinal change in height of men and women: Implications for interpretation of the body mass index. Am J Epidemiol 1999;150:969-77.

Spiegelman D, Israel RG, Bouchard C, Willett WC. Absolute fat mass, percent body fat, and body-fat distribution: Which is the real determinant of blood pressure and serum glucose? Am J Clin Nutr 1992;55:1033-44.

Stam-Moraga MC, Kolanowski J, Dramaix M, De Henauw S, De Bacquer D, De Backer G, Kornitzer MD. Trends in the prevalence of obesity among Belgian men at work, 1977-1992. Int J Obes Relat Metab Disord 1998;22:988-92.

Stam-Moraga MC, Kolanowski J, Dramaix M, De Backer G, Kornitzer MD. Sociodemographic and nutritional determinants of obesity in Belgium. Int J Obes Relat Metab Disord 1999;23:S1-9.

Steward AW, Jackson RT, Ford MA, Beaglehole R. Underestimation of relative weight by use of self-reported height and weight. Am J Epidemiol 1987;125:122-6.

Striegel-Moore RH, Shreiber GB, Pike KM, Wilfley DE, Rodin J. Drive for thinness in black and white pre adolescent girls. Int J Eat Disord 1995;18:59-69.

Sundquist J, Johansson S-E. The influence of socioeconomic status, ethnicity and lifestyle on body mass index in a longitudinal study. Int J Epidemiol 1998;27:57-63.

Swinburn B, Ashton T, Gillespie J, Cox B, Menon A, Simmons D, Birkbeck J. Health care costs of obesity in New Zealand. Int J Obes Relat Metab Disord 1997;21:891-6.

Tavani A, Negri E, La Vecchia C. Determinants of body mass index: a study from Northern Italy. Int J Obes Relat Metab Disord 1994;18:497-502.

Taylor CB, Jatulis DE, Winkleby MA, Rockhill BJ, Kraemer HC. Effects of life-style on body mass index change. Epidemiol 1994;5:599-603.

Taylor RW, Keil D, Gold EJ, Williams SM, Goulding A. Body mass index, waist girth, and waist-to-hip ratio as indexes of total and regional adiposity in women: evaluation using receiver operating characteristic curves. Am J Clin Nutr 1998;67:44-9.

Tremblay A, Buemann B, Thériault G, Bouchard C. Body fatness in active individuals reporting low lipid and alcohol intake. Eur J Clin Nutr 1995;49:824-31.

Vague J. The degree of masculine differentiation of obesities: a factor determining predisposition to diabetes, atherosclerosis, gout, and uric calculous disease. Am J Clin Nutr 1956;4:20-34.

Valdez R, Seidell JC, Ahn YI, Weiss KM. A new index of abdominal adiposity as an indicator of risk for cardiovascular disease. A cross-population study. Int J Obes Relat Metab Disord 1993;17:77-82.

van der Kooy K, Seidell JC. Techniques for the measurement of visceral fat: a practical guide. Int J Obes Relat Metab Disord 1993;17:187-96.

van der Kooy K, Leenen R, Seidell JC, Deurenberg P, Droop A, Bakker CJG. Waist-hip ratio is a poor predictor of changes in visceral fat. Am J Clin Nutr 1993;57:327-33.

Vanltallie TB. Waist circumference: a useful index in clinical care and health promotion. Nutr Rev 1998;56:300-2.

Vartiainen E, Jousilahti P, Alfthan G, Sundvall J, Pietinen P, Puska P. Cardiovascular risk factor changes in Finland, 1972-1997. Int J Epidemiol 2000;29:49-56.

Wamala SP, Wolk A, Orth-Gomér K. Determinants of obesity in relation to socioeconomic status among middle-aged Swedish women. Prev Med 1997;26:734-44.

Wardle J, Griffith J. Socioeconomic status and weight control practices in British adults. J Epidemiol Community Health 2001;55:185-90.

Wareham NJ, Rennie KL. The assessment of physical activity in individuals and populations: why try to be more precise about how physical activity is addressed? Int J Obes Relat Metab Disord 1998;22:S30-8.

Westerterp KR, Prentice AM, Jéquier E. Alcohol and body weight. In: Macdonald I, ed. Health issues related to alcohol consumption. 2nd ed. London: Blackwell Science Ltd, 1999:104-23.

WHO MONICA Project Principal Investigators. The World Health Organization MONICA Project (monitoring trends and determinants of cardiovascular disease): A major international collaboration. J Clin Epidemiol 1988;41:105-14.

Wietlisbach V, Paccaud F, Rickenbach M, Gutzwiller F. Trends in cardiovascular risk factors (1984-1993) in a Swiss region: Results of three population surveys. Prev Med 1997;26:523-33.

Willet WC. Is dietary fat a major determinant of body fat? Am J Clin Nutr 1998;67:S556-62.

Willett WC. Anthropometric measures and body composition. In: Willett WC, ed. Nutritional epidemiology. 2nd ed. New York: Oxford University Press, 1998:244-72.

Willett WC, Manson JE, Stampfer MJ, Colditz GA, Rosner B, Speizer FE, Hennekens CH. Weight, weight change and coronary heart disease in women. Risk within the 'normal' weight range. JAMA 1995;273:461-5.

Willett WC, Dietz WH, Colditz GA. Guidelines for healthy weight. N Engl J Med 1999;341:427-34.

Williamson DF. Dietary intake and physical activity as "predictors" of weight gain in observational, prospective studies of adults. Nutr Rev 1996;54:S101-9.

Williamson DF, Kahn HS, Remington PL, Anda RF. The 10-year incidence of overweight and major weight gain in US adults. Arch Intern Med 1990;150:665-72.

Williamson DF, Madans J, Anda RF, Kleinman JC, Giovino GA, Byers T. Smoking cessation and severity of weight gain in a national cohort. N Engl J Med 1991;324:739-45.

Williamson DF, Madans J, Anda RF, Kleinman JC, Kahn HS, Byers T. Recreational physical activity and ten-year weight change in a US national cohort. Int J Obes Relat Metab Disord 1993;17:279-86.

Williamson DF, Madans J, Pamuk E, Flegal KM, Kendrick JS, Serdula MK. A prospective study of childbearing and 10-year weight gain in US white women 25 to 45 years of age. Int J Obes Relat Metab Disord 1994;18:561-9.

Wilson BD, Wilson NC, Russell DG. Obesity and body fat distribution in the New Zealand population. NZ Med J 2001;114:127-30.

Wolf AM, Colditz GA. Social and economic effects of body weight in the United States. Am J Clin Nutr 1996;63:S466-9.

Wolf AM, Colditz GA. Current estimates of the economic cost of obesity in the United States. Obes Res 1998;6:97-106.

Wolk A, Rössner S. Obesity and self-perceived health in Sweden. Int J Obes Relat Metab Disord 1996;20:369-72.

World Health Organization. Obesity: Preventing and managing the global epidemic. Geneva: World Health Organization, 2000 (WHO Technical Report Series 894).

Yanai M, Kon A, Kumasaka K, Kawano K. Body mass index variations by age and sex, and prevalence of overweight in Japanese adults. Int J Obes Relat Metab Disord 1997;21:484-8.